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USER'S MANUAL FOR SIG: SHARC IMAGE GENERATOR

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13. ABSTRACT *(Maximum 200 words)*
The SHARC Image Generator, SIG, provides the user with the ability to generate synthetic non-stationary structured infrared (IR) scenes using the Strategic High Altitude Atmospheric Radiance Code (SHARC) computations. SIG is an integrated set of program modules that provides a host of options for rendering stochastic LIMB, NADIR, and Off-NADIR structured images. SIG employs an interactive menuing front-end that allows the user to specify sensor pixel size, resolution, aspect, and viewing geometry. It uses SHARC parameter output files as input specifiers. SIG employs power spectral density (PSD) function filters whose parameters may be specified by the user or by SHARC. The filters are processed using a combination of classical and parametric digital spectral synthesis techniques.

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1 INTRODUCTION

Stochastic atmospheric fluctuations in wind speed, temperature, and density can be characterized by continuous power spectral density functions. Such spectra, parameterized by spectral slope, variance, and correlation lengths are often used in simulating an environment or predicting atmospheric structure. Multidimensional fast Fourier transform synthesis provides a means for filtering white noise with spatial filters to simulate a stationary time or spatial data set. Autoregression synthesis provides a fast means for simulating *non-stationary* spatial structure sequences. Both techniques are available in the SHARC Image Generator, SIG, for rendering 2-D infrared (IR) synthetic structured images.

The Phillips Laboratory Strategic High Altitude Atmospheric Radiance Code (SHARC)[1] uses first principles to calculate point to space and limb viewing atmospheric background infrared (IR) radiance and transmittance under both local-thermal-equilibrium (LTE) and non-local-thermal-equilibrium (NLTE) conditions above 50 km.

SHARC[2] Release 4.0 has the ability to provide estimates of atmospheric infrared volume-emission perturbations caused by fluctuations in temperature and density of the contributing molecular species. The code has a capability to evaluate radiance structure parameters from estimated variances in the standard temperature and density profiles. The algorithms simulate IR fluctuations that depend on relatively small fluctuations in atmospheric species number densities, vibrational state populations, and the kinetic temperatures along a given line-of-sight[3]. Where NLTE effects dominate, (generally above 50 km) a small fluctuation

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[1]Sharma, R.D., Gruninger, J.H., Sundberg, R.L., Duff, J.W., Bernstein, L.S., Robertson, D.C., Healey, R.J., (1991) *Description of SHARC-2, The Strategic High Altitude Atmospheric Radiance Code*, Phillips Laboratory technical report, PL-TR-91-2071, ADA 239008.

[2]Sundberg, R.L., Gruninger, J., De, P., Brown, J.H., (1994) Infrared Radiance Fluctuations In The Upper Atmosphere, *Proceedings SPIE - The International Society of Optical Engineering*, V2223, April 1994, Orlando, Florida.

[3]Sears, R.D., Strugala, L.A., Newt, J., Robertson, D., Brown, J.H., Sharma, R., (1994) Simulation of the Infrared Structured Earthlimb Background Using the SHARC Radiance Code, 32nd Aerospace Sciences Meeting and Exhibit, Reno, NV, January 1994.

in kinetic temperature can produce correlated, anti-correlated, or no change in the vibrational state temperature. Such changes ultimately depend on the relative contributions from total number density, temperature-dependent kinetic rates, and radiative relaxation. A proper description of the temperature-density-radiance field as viewed from a point sensor is thus essential to enable SHARC to correctly compute the radiance structure field.

To generate realistic but practical synthetic two-dimensional non-stationary IR structure scenes, SIG provides the user with a host of options for rendering stochastic LIMB, NADIR, and Off-NADIR images. SIG employs an interactive menuing front-end that allows the user to specify sensor pixel size, resolution, aspect, and viewing geometry. SIG allows the user to generate large 3-D non-stationary temperature fluctuation databases that have non-stationary temperature PSD specifiers. The 3-D temperature database may further be used to render 2-D IR images by asking SIG to integrate the product of the localized temperature fluctuations and SHARC estimates of the radiance response functions along each pixel line-of-sight (LOS). Alternatively, SIG allows the user to render 2-D IR images directly from SHARC computations of the non-stationary radiance PSD specifiers. Three rendering methods are available for the LIMB viewing geometry, one for NADIR, and one for OFF-NADIR. These various methods include a "brute force" approach, a "stretched space" mapping transformation, and a radiance 3-D "slicing" method. SIG also provides the user with flexibility in calling for classical (FFT) or dynamic parametric (auto-regressive) filtering. This manual relies upon the results expressed in four previous reports that dealt with one-dimensional autoregression[4], two-dimensional autoregression/moving average[5], three-dimensional hybrid[6], and "stretched space"[7] structure simulation.

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[4]Brown, J.H., (1993) *Atmospheric Structure Simulation: An Autoregressive Model for Smooth Geophysical Power Spectra with Known Autocorrelation Function*, Phillips Laboratory technical report, PL-TR-2185, ERP#1128, ADA 276691.

[5]Brown, J.H., (1993) *Atmospheric Structure Simulation: An ARMA Model for Smooth Isotropic Two-Dimensional Geophysical Power Spectra*, Phillips Laboratory technical report, PL-TR-93-2224, ERP#1132, ADA 280476.

[6]Brown, J.H., (1994) *Synthetic 3-D Atmospheric Temperature Structure: A Model for Known Geophysical Power Spectra Using a Hybrid Autoregression and Fourier Technique*, Phillips Laboratory technical report PL-TR-94-2150, ERP#1150, ADA 289058.

[7] Brown, J.H., and Grossbard, N.J., (1996) *Fast "stretched space" method for generating synthetic verical sheets of nonstationary stochastic atmospheric structure for infrared background scene simulation*, Opt. Eng., Vol 35, No 4, pp 1035-1043.

2 SHARC Image Generator (SIG): Image Synthesis

SIG, the SHARC Image Generator, is a new Phillips Laboratory interactive menu driven FORTRAN code that interfaces with SHARC V4.0 and higher. It renders 2-D IR Non-Stationary Stochastic Structure scenes. SIG provides for a user specified sensor array size and viewing geometry. It is physically based in the sense that the synthetic scenes depend on the first principles of SHARC chemistry and radiation transfer and invokes current gravity wave understanding of the power spectral density functions of atmospheric perturbations. SIG is also measurement based in that it uses the Nonstationary Stochastic (NSS) variance and correlation length estimates of Sears, et.al.[3] Although SIG uses the NSS estimates, alternative models can be easily accommodated.

The difficulty of generating 2-D synthetic IR structure issues from the response of 3-D IR spatial structure to localized nonstationary 3-D atmospheric fluctuations of atmospheric density and temperature. Since the statistics of atmospheric structure are nonstationary and since there exists limited information on the high altitude structure statistics, including temperature and radiance covariance functions, PDF's, PSD's, and their derivative quantities (shape, variances, and correlation lengths), unknown uncertainties indwell in the synthetic radiance images. Sears[3] has estimated a factor of 3 for the $\pm 1\sigma$ level for the temperature fluctuations.

Depending upon the desired sensor viewing geometry, and acceptable tradeoffs between fidelity and computational speed, various optional approaches have been taken to generate the non-stationary, stochastic, synthetic images. For example LIMB views may be generated from a slow but high fidelity "brute Force" approach where LOS integrations are performed for every pixel through a three dimensional field of temperature fluctuations. A quicker LIMB approach, that invokes additional assumptions, generates the two-dimensional synthetic radiance image from an FFT/dynamic autoregressive combination that uses SHARC computations for the radiance statistical and PSD specifiers. A fast third approach for the LIMB view depends upon a transformed "stretched-space" algorithm described below in which an image is generated in "stretched" stationary space and then transformed to the prescribed space in which the fluctuations are non-stationary. NADIR views are synthesized from 2-D FFT algorithms, while downlooking OFF-NADIR views are synthesized from a transformed three dimensional "slicing" approach described below. To summarize, SIG provides an array of rendering options as presented in the following table.

LIMB VIEWING	NADIR VIEWING	OFF-NADIR VIEWING
Vert. Non- Stationary H/V Separable AR Vert. x 2-D FFT Horiz. "Brute Force Method" 3-D Integrations	Stationary Scene H/V Non-Separable Isotropic 2-D FFT	Vert. Non- Stationary H/V Non-Separable Hor. Isotropic Project 2-D Radiance plane to 3-D Radiance array, separable in 3-D. Transform & remap.
"2-D Dynamic AR Modeling" AR Vert. x FFT Horiz. AR Vert. x AR Horiz.		AR x 2-D FFT Method or Stretched Space x 2-D FFT Method Slice 3-D Field Along Original Image Plane
"Stretched Space" Transform AR x AR, AR x FFT, FFT x AR, FFT x FFT		

Table 1. SIG Optional Capabilities

2.1 OPTIONAL LIMB VIEW METHODS

As mentioned above, the user may choose one of three possible paths for rendering LIMB radiance structure: a "brute force" calculation, a dynamic autoregressive modeling, or a "stretched space" mapping technique. In the SHARC-SIG flow diagram (Figure 1) below, the "brute force" approach is shown as path "A". In this approach, SHARC uses local chemistry to compute path dependent values of "apparent radiance volume emission", V_e, and "radiance apparent fluctuation amplitude", F_A. SIG then uses V_e, F_A, and NSS estimates of the 3-D temperature variance, and horizontal and vertical correlation lengths to render the 2-D radiance scene. Alternatively, the dynamic autoregressive approach is shown as path "B". Here SHARC uses NSS estimates of the temperature covariance function to compute radiance variance, and scene coordinate horizontal and vertical correlation lengths. SIG uses these estimates in a dynamic AR filter to render the 2-D radiance scene. Path B is significantly faster than path A but depends more upon assumptions relating the temperature covariance functions to the radiance covariance functions.

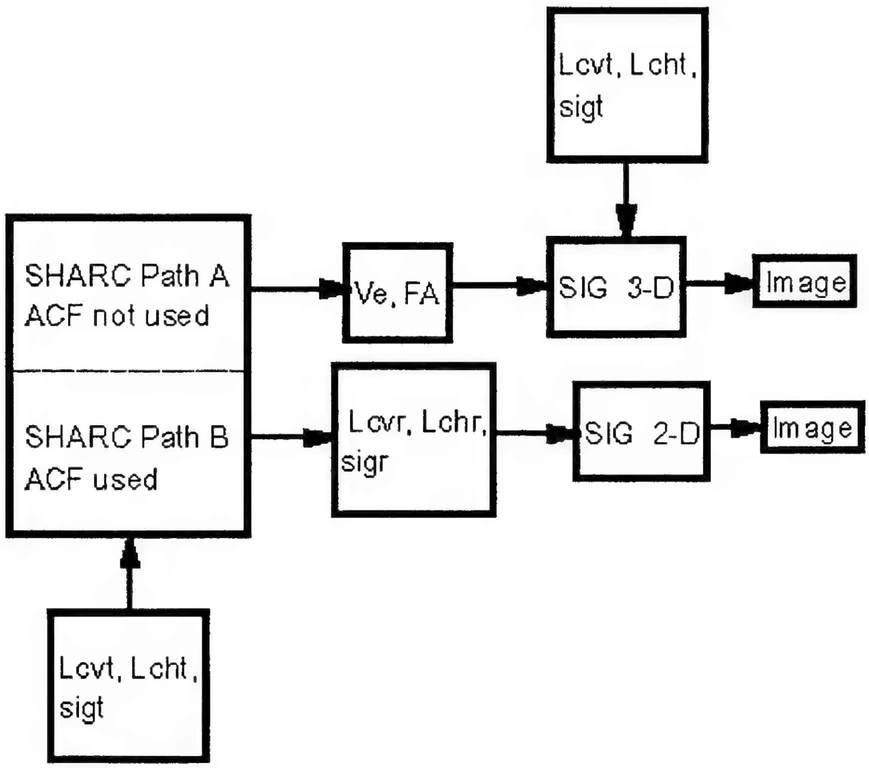

Figure 1. SHARC-SIG Flow Diagram

2.1.1 Brute Force Three-Dimensional LIMB Approach

The bandpass dependent simulation of the radiance fluctuations observed by an imaging sensor may be calculated by generating a three-dimensional realization of the atmospheric temperature and density fluctuations and by intersecting a LOS for each pixel in the sensor. Though isotropic in the two dimensional horizontal direction, the temperature structure statistics are non-stationary and anisotropic in the vertical direction. This requires that SIG deal with spatially varying statistics and PSD's. Here, inputs to SIG include the mean radiance, and NSS temperature model of horizontal and vertical correlation length, and variance for each altitude. The input temperature Power Spectral Density (PSD) function is assigned a vertical power-law slope of -3 and a horizontal power-law slope of -5/3, consistent with the present gravity-wave understanding of atmospheric temperature structure[8]. The resultant database of temperature and density fluctuations has been analyzed and validated in a previous study[6]. The model uses

[8] Dewan, E.M., "The saturated-cascade model for atmospheric gravity wave spectra, and the wavelength-period (W-P) relations", GRL Letters, 21, No. 9, pp 817-820, (May 1994).

Fourier techniques to generate (isotropic) horizontal correlations and an auto-regressive (AR) method to synthesize vertical non-stationary correlations.

First, three-dimensional Gaussian random number temperature fluctuations having a zero mean and unit variance are correlated along each column in the earth centered vertical direction using a six coefficient dynamical AR approach[6]. The AR model varies its coefficients with altitude and has 1-D (PSD) functions consistent with the specified vertical temperature correlation length for each altitude. This process produces the desired vertical non-stationary correlated stochastic temperature structure. The vertically correlated structure is then correlated in the horizontal direction using a two-dimensional Fourier approach with specified variance. Each horizontal slice is filtered by a 2-D (PSD) function having the specified horizontal temperature correlation length for each altitude. The 2-D arrays are then inverse Fourier transformed to produce the desired three-dimensional structure.

We have chosen to develop the non-stationary database in a three-dimensional matrix that is described geometrically by a segment of a sphere. The spherical segment consists of a volume defined by a radial height and whose horizontal matrix elements lie in a spherical surface at radial distance "r". Since we wish the database (i.e. synthetic atmosphere) to be applicable for observation by a modeled sensor, we orient the longer horizontal dimension along the sensor LOS direction and the shorter horizontal dimension along the direction transverse to the line-of-sight. The default spatial resolution of a matrix element has an incremental altitude of 0.2 km by an incremental transverse distance of approximately 0.2 km by an incremental LOS distance of approximately 26 km. The actual data spacing in the horizontal dimension must increase slightly with altitude so that points in the vertical dimension stay on radial lines. The user should insure that the vertical and transverse dimensions of the database are sufficient to fill the field of view of the sensor array. The vertical and transverse spatial resolution should be governed by the vertical and horizontal correlation lengths of the temperature variations and may be chosen to provide high field-of-view spatial resolution. Figure 2 is an example of the spherical geometry and Table 2 summarizes the default database specifications.

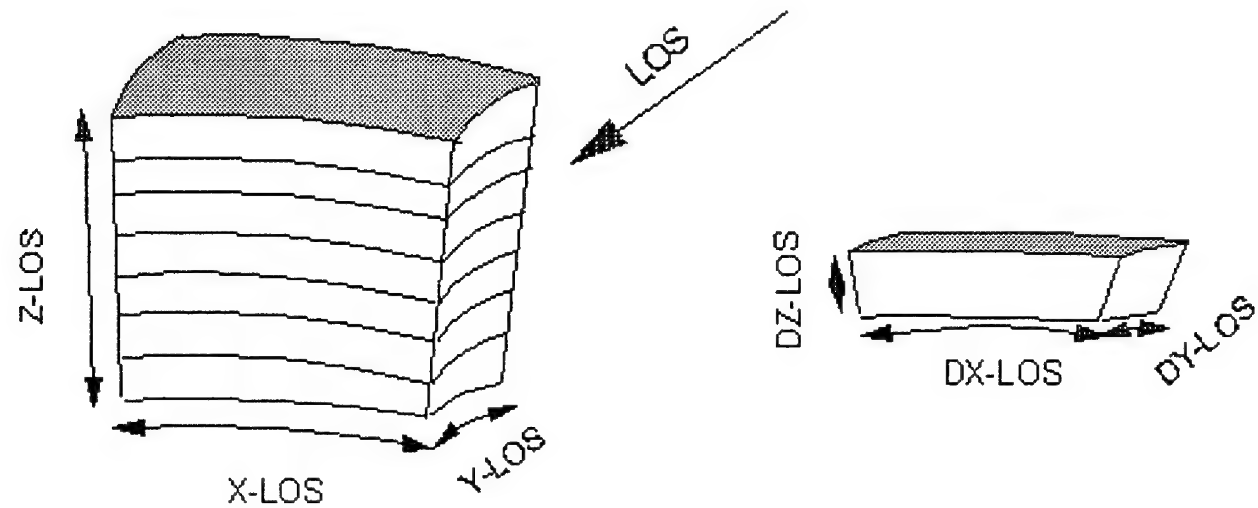

Figure 2. 3-D Temperature Database Geometry

Direction	Npts	Δx (km)	NΔx (km)
Vertical (30-250 km)	1101	0.2	220.
Transverse	1024	0.2	204.8
LOS	64	25.4 @ 30	1626 @30

Table 2. Non-Stationary, Stochastic Temperature Structure Database Default Specifications

The fluctuation amplitudes, which give the response of the radiance to temperature and density fluctuations, are computed by SHARC[9]. The radiance structure of atmospheric backgrounds is induced by local temperature and density fluctuations in the atmosphere. The radiance in a pixel of an image plane $L_{\Delta\lambda}(\vec{p})$, is given by $L_{\Delta\lambda}(\vec{p}) = \int d\lambda \int dr\, S(\vec{r},\lambda)\, \partial\tau(r,\lambda)/\partial r$. The quantity $S(\vec{r},\lambda)$ is the emission source term at wavelength λ. The atmospheric transmittance, τ, along the LOS depends on the scalar distance r from the observer to the pixel and $\vec{p}$ is a vector in the sensor plane defining the pixel location. Implicit in this equation is a sum over all species and their molecular states which emit in the bandpass, $\Delta\lambda$. A fluctuation in radiance is approximated using the lead terms of a Taylor series expansion in terms of the vibrational state temperatures and the atmospheric temperature.

$$\Delta L_{\Delta\lambda}(\vec{p}) = \int dr \left\{ \sum_j F^j_{\Delta\lambda}(\vec{r})\Delta T^j_{vib} + F^0_{\Delta\lambda}(\vec{r})\Delta T_k \right\} + O[(\Delta T_k)^2] \tag{1}$$

The $F^j_{\Delta\lambda}$ and $F^0_{\Delta\lambda}$ are local LOS fluctuation amplitude functions that are calculated by SHARC. The $F^j_{\Delta\lambda}$ and $F^0_{\Delta\lambda}$ are local LOS fluctuation amplitude functions (watt/cm^2·ster·km·K). The radiance fluctuations induced by the rearrangement of population among the molecular vibrational states, j, is given by

$$F^j_{\Delta\lambda}(\vec{r}) = \int d\lambda\, \partial[S(\vec{r},\lambda)\,\partial\tau(r,\lambda)/\partial r]/\partial T^j_{vib} \tag{2}$$

The radiance fluctuation induced by population shifts among rotational states, which are assumed to be in LTE, and the expansion or compression of the gas is given by

$$F^0_{\Delta\lambda}(\vec{r}) = \int d\lambda\, \partial[S(\vec{r},\lambda)\,\partial\tau(r,\lambda)/\partial r]/\partial T_k \tag{3}$$

Only the linear terms in Equation (1) are retained to make a direct estimate of the radiance statistics[10]. This approach is an extension of an LTE approximation used to determine atmospheric radiance statistics. The expression for radiance fluctuation can be simplified in the linear approximation to

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[9] Gruninger, J.H., Sundberg, R.L., Duff, J.W., Brown, J.H., Sharma, R., Sears, R.D., "Modeling for atmospheric background radiance structures", SPIE Proceedings *Optics in Atmospheric Propagation and Adaptive Systems*, 2580, pp 2-16, Paris, France (September 1995).

[10] R. L. Sundberg, J. H. Gruninger and J. H. Brown, "Infrared Radiance Fluctuations in the upper Atmosphere", SPIE Proceedings of the International Symposium on Optical Engineering in Aerospace Sensing 2223, Orlando, FL (April 1994).

$$\Delta L_{\Delta\lambda}(\vec{p}) = \int dr\, F_{\Delta\lambda}(\vec{r})\Delta T_k \tag{4}$$

where $F_{\Delta\lambda}(\vec{r})$ includes radiance fluctuation contributions from both vibrational state temperature fluctuations and kinetic temperature fluctuations.

$$F_{\Delta\lambda}(\vec{r}) = \sum_j F^j_{\Delta\lambda}(\vec{r})\partial T^j_{vib} \,/\, \partial T_k + F^0_{\Delta\lambda}(\vec{r}) \tag{5}$$

The fluctuation amplitude is a linear response model for radiance fluctuations in terms of gas kinetic temperature fluctuations. This model can be coupled with a statistical model for non-stationary atmospheric temperature fluctuations to obtain a statistical non-stationary description of radiance fluctuations. The integral of the temperature covariance function yields the temperature correlation length along the LOS direction, $\ell_{r,T}(\vec{r})$. The statistical properties of the radiance fluctuations such as correlation angles or lengths can be determined directly from the covariance function. The structured two-dimensional radiance field is then constructed from the fluctuation amplitudes and 3-D realization of the temperature and density fluctuations. Line-of-sight integrations are then performed for each sensor pixel to generate a radiance image corresponding to the sensor specifications. This "brute force" process is computer intensive and slow compared with other methods described here but it makes use of the more fundamental SHARC computations of radiance fluctuation amplitudes. It does not use the SHARC estimates of radiance correlation lengths and variance, and it depends upon fewer assumptions.

2.1.1.1 PSD Model Discussion

Atmospheric power spectral density functions often are modeled by three parameter isotropic one-dimensional double-sided power law functions of the form[11,12]:

$$PSD(k) = \frac{\sigma^2 a^{2\nu}\Gamma(\nu+1/2)}{\sqrt{\pi}\Gamma(\nu)\left(a^2+k^2\right)^{\nu+1/2}}, \tag{6}$$

Here k represents spatial frequency, σ^2 represents variance, ν determines the asymptotic power law dependence, and a is a parameter that determines the "low frequency" PSD shape. The relationship between the frequency domain PSD and

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[11]Tatarski, V.I., (1961) *Wave Propagation in a Turbulent Medium*, Eq. 1.11, McGraw-Hill.

[12]Futterman, W.I., Schweitzer, E.L., Newt, J.E., (1991) Estimation of Scene Correlation Lengths, Characterization, Propagation, and Simulation of Sources and Backgrounds, *Proceedings SPIE - The International Society of Optical Engineering*, V1486, pp127-140, April 1991, Orlando, Florida.

‡ Reference 4 describes the correlation length as the equivalent width of the autocorrelation function, pp. 5-6.

the time or spatial domain autocorrelation function is specified by their Fourier transform pairs. Thus the autocorrelation function, (*ACF*), for the real even *PSD* function is[4]:

$$ACF(s) = \frac{\sigma^2 2^{(1-\nu)}(2\pi\, as)^\nu K_\nu(2\pi\, as)}{\Gamma(\nu)}, \tag{7}$$

where K_ν is the Bessel function of the second kind of fractional order. In this form the *PSD* and *ACF* are stationary and independent of altitude The parameter "*a*" can be expressed in terms of the integral scale, *L*, of the autocorrelation function such that, $a = \frac{\Gamma(\nu + 1/2)}{2\sqrt{\pi}\Gamma(\nu) * L_c}$. For the moment we assume "*a*" is a constant and "L_c" is a measure of the "correlation length"‡. The above may be rewritten as:

$$ACF(s) = \frac{\sigma^2 2^{(1-\nu)}}{\Gamma(\nu)} \left(\frac{\Gamma(\nu + 1/2) 2\pi s}{\Gamma(\nu) 2\sqrt{\pi} L_c} \right)^\nu K_\nu \left(\frac{\Gamma(\nu + 1/2) 2\pi s}{\Gamma(\nu) 2\sqrt{\pi} L_c} \right)$$

or, $$ACF(s) = B \left(C \frac{s}{L_c} \right)^\nu K_\nu \left(C \frac{s}{L_c} \right) \tag{8}$$

where $B = \frac{\sigma^2 2^{(1-\nu)}}{\Gamma(\nu)}$ and, $C = 2\pi \left(\frac{2\sqrt{\pi}\Gamma(\nu)}{\Gamma(\nu + 1/2)} \right)^{-1}$.

2.1.1.2 3-D Temperature Structure Database

Conceptually, radial line segments having an origin at the center of the earth, define a segment of a sphere. Along the geometrical set of these radial or vertical line segments, a spatial data sequence is simulated using a normally distributed set of pseudorandom numbers *G*(*J*). The set of random numbers is initialized by a user specified seed. The sequence, *G*(*J*), contains different random numbers for each line. *G*(*J*) consists of a mean equal to zero and variance equal to 1. Simulation of the sequence values along each vertical (radial) line is generated from a user specified pth order autoregressive filter by the expression: $Y(J) = G(J) - \sum_{j=1}^{p} a_j Y(J - j)$ where the a_j values are determined from the Levinson algorithm described in appendix A. Note that the first level of non-stationarity is built into the database by allowing the a_j values to dynamically change with altitude as a function of the vertical correlation length. The first 51 values of Y(J) for each radial line are discarded to allow for filter relaxation. In practice, the

calculational scheme steps along each altitude layer. First the vertically correlated component for a particular layer (the top layer in the array) is computed with $\sigma^2 = 1$. The layer is then copied to a second array where the appropriate horizontal correlation and σ^2 are applied for that layer. Since σ^2 and horizontal correlation length changes with altitude, these parameters are applied to the horizontal layer in the copied array to account for the second level of non-stationarity. Thus each layer in the copied array contains both the vertical and horizontal correlations before proceeding to the next higher layer. The scheme is represented in Figure 3.

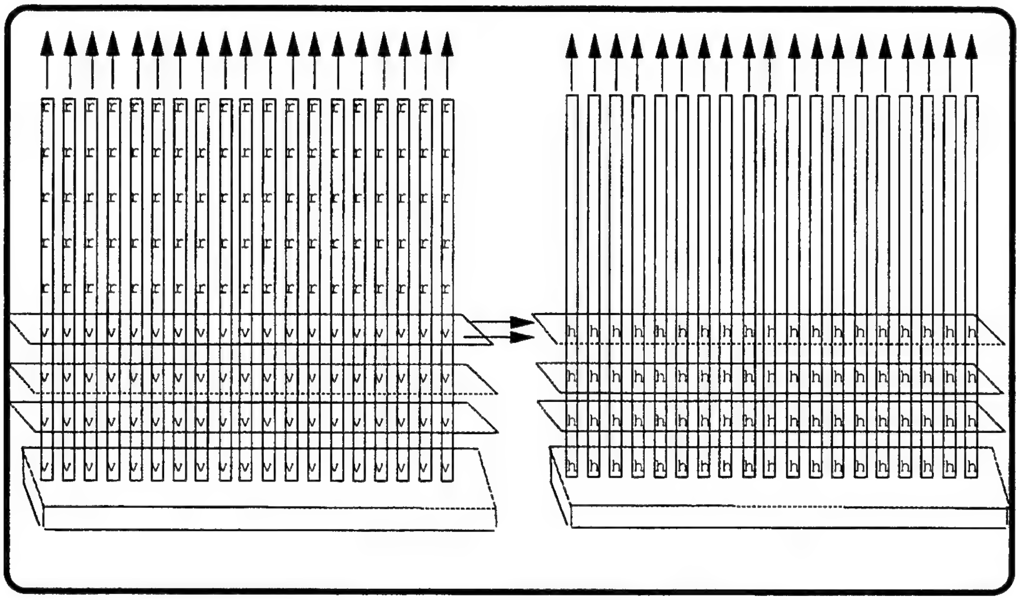


Figure 3. 3-D Temperature Structure Database Calculation Scheme. First, correlations along the vertical lines are calculated (one layer at a time) and then the horizontal correlation calculation is applied to each layer.

The altitude dependence of the relative temperature variance, horizontal correlation length, and vertical correlation length are adopted from Strugala, et.al.[13,14].

The correlations in the horizontal LOS direction, ℓ, and transverse direction, t, are applied to the previous vertically correlated simulated data by using two-dimensional Fourier transform synthesis. The model autocorrelation function used

[13]Strugala, L.A., "Development of High Resolution Statistically Non-stationary Infrared Earthlimb Radiance Scenes", Characterization, Propagation, and Simulation of Sources and Backgrounds, Proceedings SPIE - The International Society for Optical Engineering, V1486, pp. 176-187, April 1991, Orlando, Florida.

[14]Strugala, L.A., (1993) *Production of statistically nonstationary stochastic structure realizations for infrared background scene simulations*, Optical Engineering, V32, No5, pp. 993-1001, May 1993.

in SIG leads to an isotropic two-dimensional power spectral density function given by:

$P\left(k_{t,\ell}\right)=\dfrac{\sigma^2 v a^{2v}}{\pi\left(a^2+k_t^2+k_\ell^2\right)^{v+1}}$, *for* $-\infty \le k_t, k_\ell \le \infty$. This representation replaces the one-dimensional -(2v+1) power dependence with a two-dimensional -(2v+2) power dependence. $P(k_{t,\ell})$ is used to filter the vertically correlated Gaussian random values at a given altitude. First, the procedure finds the two-dimensional Fast Fourier Transform (FFT) of the two-dimensional Gaussian correlated values at a given altitude. These spatial frequency values then are multiplied by the filter function $\sqrt{P(k_t,k_\ell)/\Delta t \Delta \ell}$. A two-dimensional inverse Fourier Transform of the result gives the final correlated simulated data at a given altitude. The process steps up in altitude to yield the three-dimensional database. Summarizing, the simulated data, $S(t,\ell)$, for a layer is described by the following:

$S(t,\ell)=FFT^{-1}\left(\sqrt{\dfrac{P_{theor}(k_t,k_\ell)}{\Delta t \Delta \ell}}\times FFT\left(\tilde{G}(\varepsilon_t,\varepsilon_\ell)\right)\right)$, where $\tilde{G}(\varepsilon_t,\varepsilon_\ell)$ are the vertically correlated simulated data for the layer. *As explained in the appendix A, sampling theory results cause us to modify the expression for* $S(t,\ell)$.

2.1.2 Two-Dimensional Dynamic Autoregressive/Fourier LIMB Approach

This method uses additional SHARC estimates of the image plane radiance statistics to generate synthetic two-dimensional radiance images. Although much faster than the three-dimensional approach, it is somewhat more removed from local processes. This method holds that the vertical and horizontal model radiance PSD's are separable, non-stationary, and anisotropic.

The radiance covariance $Cov_L(\vec{p}_1,\vec{p}_2)$, where $\vec{p}_1$ corresponds to point 1, and $\vec{p}_2$ to point 2, in the sensor plane, can be expressed as[9]

$$Cov_L(\vec{p}_1,\vec{p}_2)=E[\Delta L_{\Delta\lambda}(\vec{p}_1)\Delta L_{\Delta\lambda}(\vec{p}_2)] \tag{9}$$

where E is the expectation value. Substituting Equation (4) into Equation (9) yields

$$Cov_L(\vec{p}_1,\vec{p}_2)=\int dr_1\int dr_2 F_{\Delta\lambda}(\vec{r}_1)F_{\Delta\lambda}(\vec{r}_2)Cov_T(\vec{r}_1,\vec{r}_2) \tag{10}$$

The radiance variance, $\sigma_L^2(\vec{p})$, is determined by setting $\vec{p}_1=\vec{p}_2$ in Equation (10) so there is zero lag

$$\sigma_L^2(\vec{p})=\int dr\int dr' F_{\Delta\lambda}(\vec{r})F_{\Delta\lambda}(\vec{r}\,')Cov_T(\vec{r},\vec{r}\,') \tag{11}$$

The approach sets up a two-dimensional array of random numbers that are filtered in the image vertical direction by a user specified dynamic pth order autoregressive (AR) process. The p AR coefficients change with vertical distance depending upon the varying vertical radiance correlation lengths as computed by SHARC. Each row of the vertically correlated array is then filtered in the horizontal direction by 1-D FFT's (alternately, 1-D AR filters) that depend upon the horizontal radiance correlation lengths and variances as computed by SHARC.

2.1.3 Two-Dimensional "Stretched-Space" Fixed AR/Fourier LIMB Approach

The benefit of the "stretched-space" transformation is that it requires just a single 2-D filter pass in stationary space to generate the entire structure. Thus the *real* altitude can be "mapped" into a *stretched space*, where the radiance autocovariance function is stationary. Rather than using multiple AR or FFT filter passes to generate the non-stationary 2-D structure, the stretched-space transformation allows us to synthesize correlated structure using just one pass in the transformed vertical dimension. Again, the method presupposes that the vertical and horizontal model radiance PSD's are separable. The method is quite fast but mapping back to the equally spaced vertical points in "normal" space from the equally spaced stretched points requires linear interpolation and thus slight smoothing of the structure. This approach uses FFT or AR filters for the vertical and horizontal dimensions and was detailed in another report[7] but is summarized below.

2.1.3.1 The *"Stretched Space"* Transformation

Under "stationary" conditions, the autocovariance function (ACF) is not a function of the altitude, "*z*". The autocorrelation function, with index *s* corresponding to *z* is

$$ACF(s) = E[f(z)f(z+s)] \tag{12}$$

where *f* is a continuous range of random values. For the stationary condition, we assume that $f(z)$ is ergodic and we can estimate $ACF(s)$ by:

$ACF(s) = \frac{1}{2N+1}\sum_{i=-N}^{N}\{f(z_i)f(z_i+s)\}$, when $f(z)$ is discrete, where, $z_i = i * \Delta z$, with Δz the spacing between the z_i levels.

Under nonstationary conditions the ACF depends on altitude, *z* such that $ACF(z,s) = E[f(z)f(z+s)]$. The stretched space method transforms the lag "*s*" to the new lag variable "*y*" by the function: $y = y(z,s)$ which has an inverse transform $s(z,y) = y^{-1}(z,s)$. SIG transforms the altitude "*z*" to a space "*t*" by the monotonic function: $t = t(z)$, where *y* has uniform spacing in *t*. These transforms provide the stationary autocovariance function $ACF(y)$:

$$ACF(y) = E[f(t)f(t+y)] \tag{13}$$

Where the parameter L_c in equation (7) is no longer constant but depends on altitude z, the parameter "a" in equation (6) depends upon z, which renders the *PSD* non-stationary. Rewriting equation (8) for a "correlation length", $L_c(z,s)$, that depends upon the altitude z and lag s, the non-stationary autocovariance function $ACF(z,s)$ becomes:

$$ACF(z,s) = B\left(C\frac{s}{L_c(z,s)}\right)^{\nu} K_{\nu}\left(C\frac{s}{L_c(z,s)}\right).$$

We assume that the "measured" parameter "a" in the equation for the *PSD* is an average over altitude, so that $a(z)$ may be defined as an average of the reciprocal of L_c: $a(z) \propto \frac{1}{L_c(z,s)} = \frac{1}{s}\int_z^{z+s} \frac{dx}{L_c(x,0)}$, where $L_c(x,0)$ is a function of altitude.

Defining the transformation of s to y by:

$$y = y(z,s) = \overline{L_c}\int_z^{z+s} \frac{dx}{L_c(x,0)} \tag{14}$$

where $\overline{L_c}$ is a constant which will be set for convenience, then, $ACF(y) = B\left(\frac{C}{\overline{L_c}}y\right)^{\nu} K_{\nu}\left(\frac{C}{\overline{L_c}}y\right)$ which is stationary and not a function of altitude. In equation (14) we constrain L_c to positive values so that $y = y(z,s)$ is monotonic. We also assume that ν is a constant independent of altitude. $t(z)$ is found to be:

$$t(z) = t_0 + \overline{L_c}\int_{z_0}^{z} \frac{dx}{L_c(x,0)} \tag{15}$$

The limits determine $\overline{L_c}$ which is found from $\overline{L_c} = \frac{z_f - z_i}{\int_{z_i}^{z_f} \frac{1}{L_c(z,0)} dz}$.

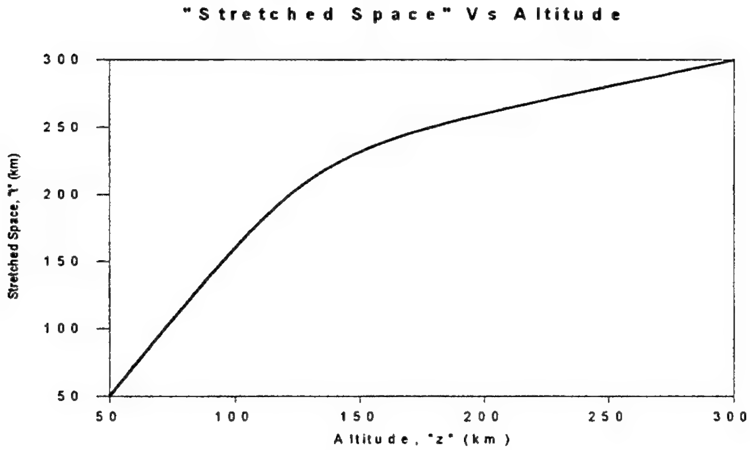


Figure 4. "Stretched Space" Vs Altitude

Thus the *real space* altitude, "z" can be "mapped" into *a stretched space*, "$t(z)$" where the autocovariance function $ACF(y)$ is stationary. Given a positive function, $L_c(z)$ (see for example reference 6), Figure 4 above plots "stretched space", t, as a monotonically increasing function of altitude, z.

2.2 NADIR Viewing Method
Two-Dimensional Fixed 2-D FFT Nadir Approach

We expect the radiance statistics of IR images from downlooking Nadir views that do not penetrate to cloud level to be isotropic and stationary. Simple 2-D FFT algorithms that use SHARC computations of a single radiance correlation length and variance for the whole image is thus sufficient. The 2-D PSD models that are used to filter 2-D arrays of Gaussian white noise are non-separable in the horizontal plane. Synthesis of nadir images are thus simple and fast and result in rather benign scenes.

2.3 OFF-NADIR Viewing Method
Downlooking Off-Nadir Approach

The vertical power spectral densities of off-nadir IR radiance images are expected to be non-stationary. The image is also expected to be anisotropic, and for large off-nadir angles, the vertical and horizontal model radiance PSD's cannot be assumed to be separable. Since the 2-D PSD's appear to be non-separable and anisotropic, a proper 2-D PSD model must be invented that retains non-separability and anisotropy. Two-dimensional dynamic autoregressive/moving average models may be invoked but we have found the process to be computationally time-consuming and generally unsatisfactory[5]. Instead, we have constructed the following approach.

A set of horizontal and vertical radiance correlation lengths and variances are computed by SHARC for each row in the scene. Knowing that the image is tilted with respect to the geodetic vertical direction, we construct a vertical three-dimensional *radiance database* (similar to the method described above for generating the 3-D temperature structure database) from properly modified correlation lengths, spacings, and PSD slopes, so that selected horizontal rows of the 3-D field correspond to the viewing geometry of the off-nadir scene. The modified vertical and LOS horizontal correlation lengths and spacings are evaluated from the triangle that the scene makes with the true vertical. The azimuthal horizontal components are left unchanged. The vertical and LOS PSD slopes are modified by an empirical relationship that has been validated with SHARC. No LOS integrations are involved (as with the 3-D *Brute-Force* limb approach). It is necessary only to select those elements of the 3-D *radiance* array that lie along the tilted plane. Figure 5 is a rough sketch of the geometries of the transformation.

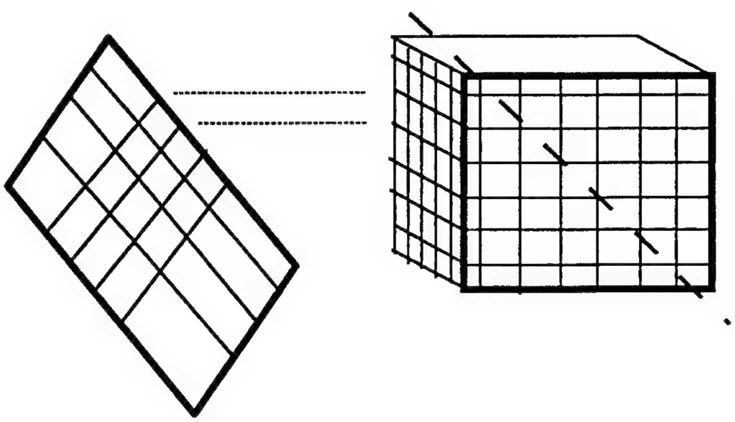
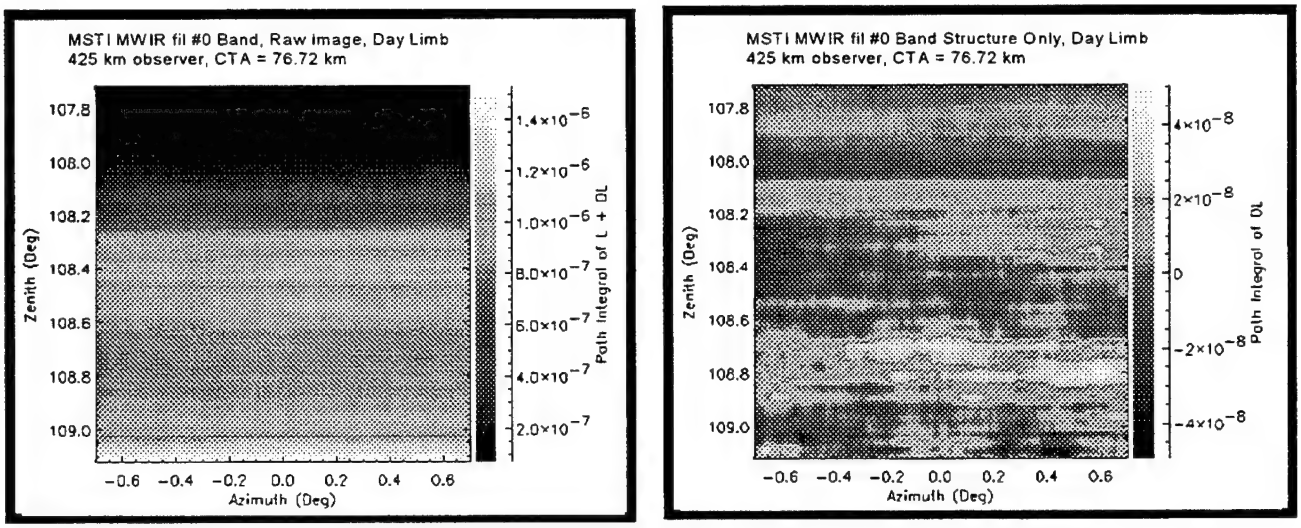


Figure 5. Off-Nadir Transformation Geometries

2.4 RADIANCE STRUCTURE STATISTICS AND IMAGES

The "brute force" SIG model described here has been applied to calculate the radiance structure of one MSTI-3 band. In Figure 6, the synthetic images show background radiance with imbedded structure in the left panel. The right panel shows the image without the background.



Deterministic Plus Stochastic Structure

Stochastic Structure

Figure 6. Synthetic Images; MSTI MWIR, Filter 0, Daytime

The "brute force" SIG model was also applied to calculate the radiance structure of one of the MSX $CO_2(\nu_3)$ bands (band B1) under daytime and nighttime conditions. The calculated profile mean radiances and variances are illustrated in Figure 7.

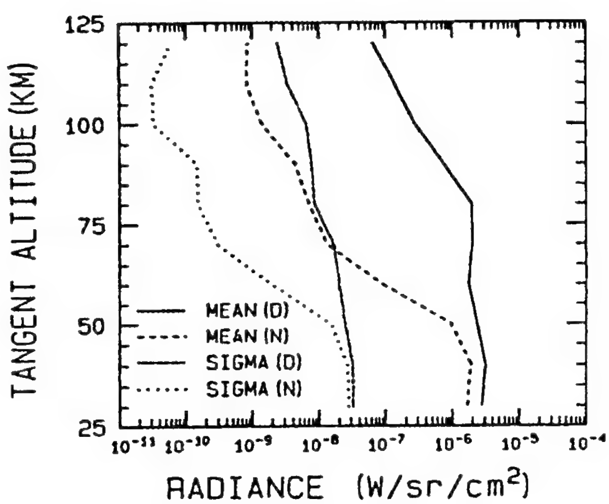


Figure 7. Calculated Profile Mean Radiances and Variances

Figures 8 and 9 show image realizations (using the SIG algorithm) of the resulting day and night radiance statistics for the CO_2 (ν_3) MSX band Bl. The dc component of the radiance has been removed to highlight the structure.

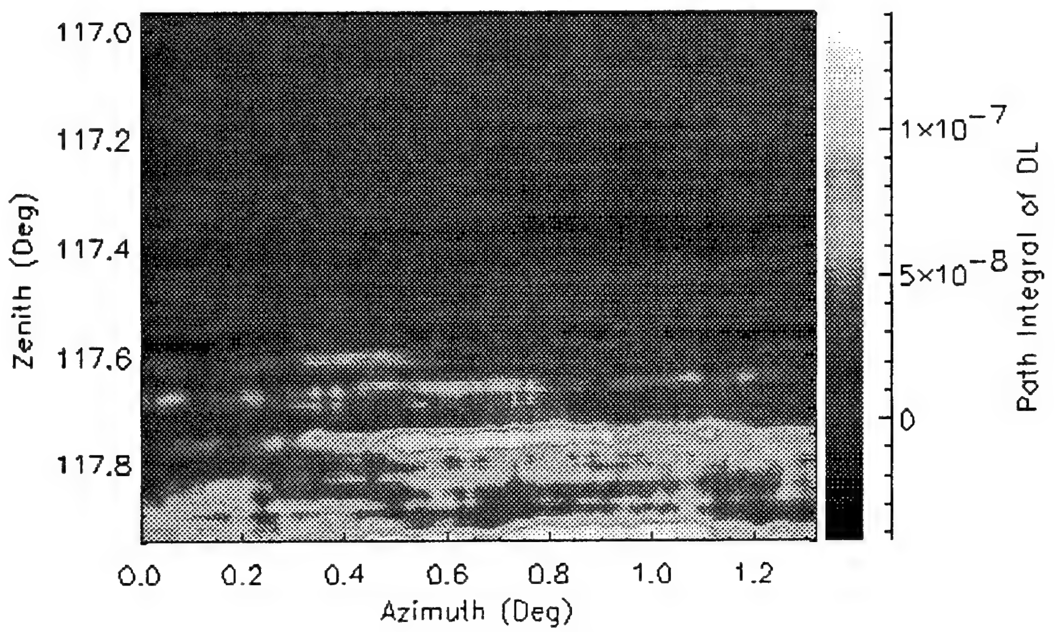


Figure 8. Synthetic Image of Radiance Structure in the $CO_2(\nu_3)$ B1 Band Radiance for Daytime Conditions

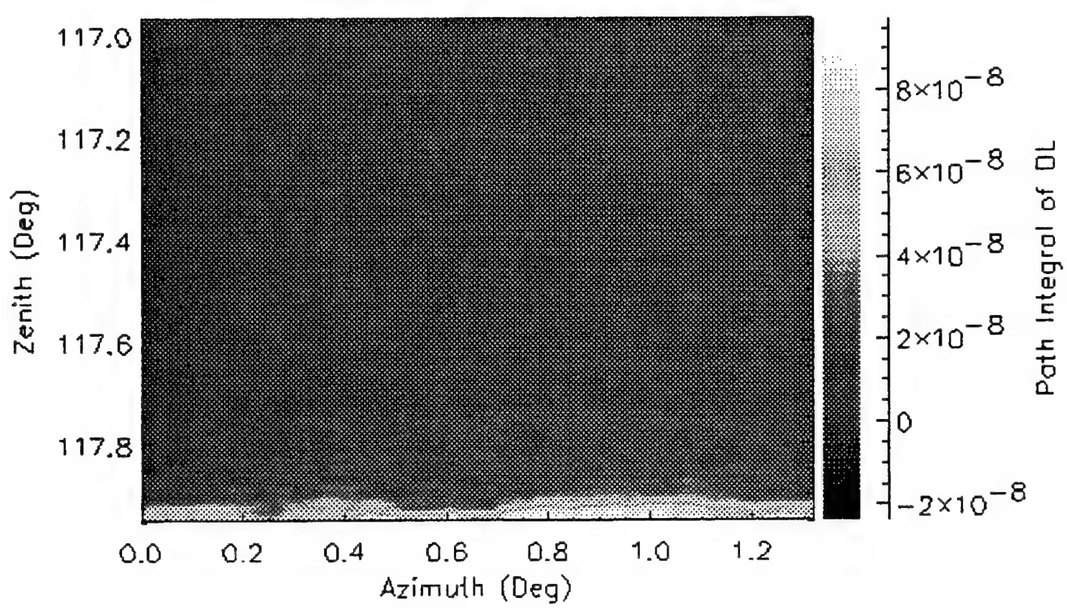
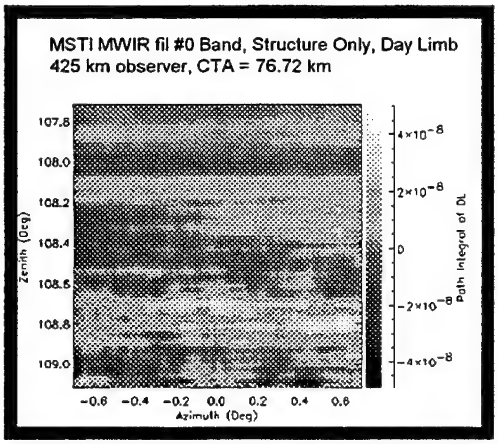
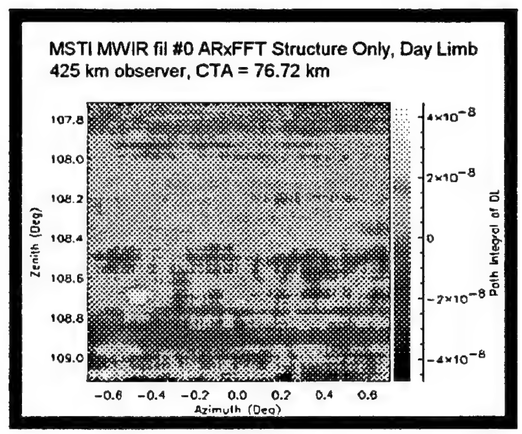


Figure 9. Synthetic Image of Radiance Structure in the $CO_2(\nu_3)$ Band Radiance for Nighttime Conditions

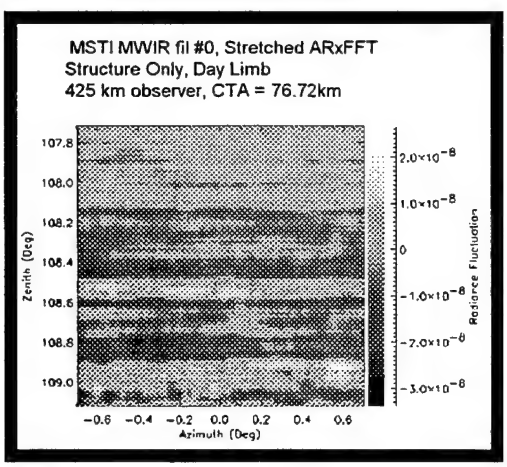
In Figure 10, the synthetic images compare structure computed for the three LIMB viewing methods, “brute force”, “Dynamic 2-D”, and “Stretched-Space”.



3-D



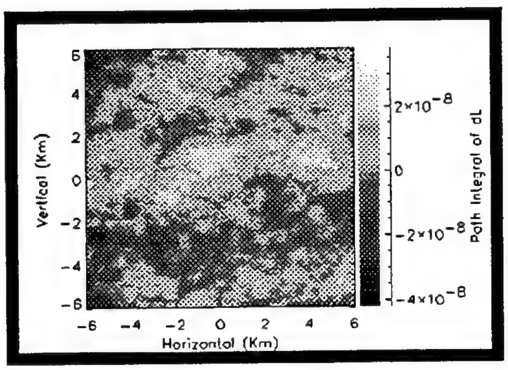
2-D Dynamic AR



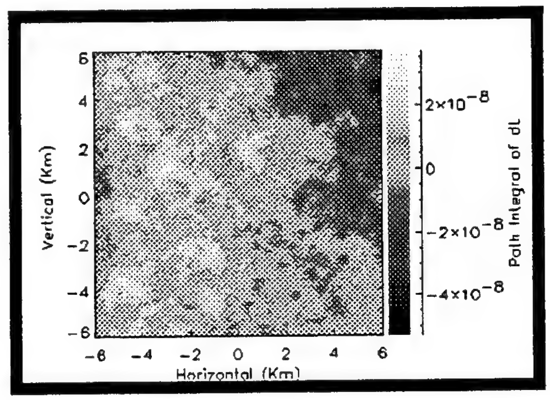
2-D Stretched Space

Figure 10. Synthetic Images; Structure Comparison, MWIR, Filter 0, Day 3-D, 2-D Dynamic AR, 2-D Stretched Space

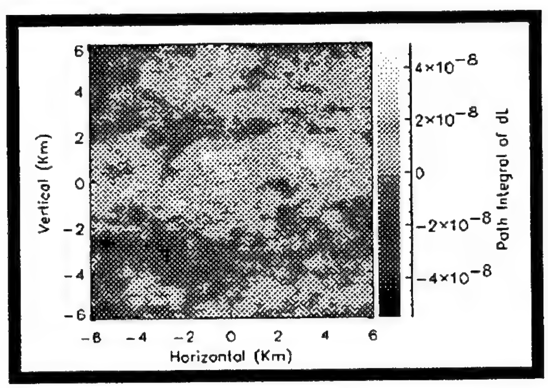
The following three images in Figure 11 are examples of NADIR and OFF-NADIR synthetic scenes.



20 deg. Off-Nadir
Non-Separable 3-D
Slicing Method



Nadir
(Isotropic)



30 deg. Off-Nadir
Non-Separable 3-D
Slicing Method

Figure 11. Synthetic Images; MSTI Downlooking Scenes

The following diagram (Figure 12) illustrates an example of a variable path geometry.

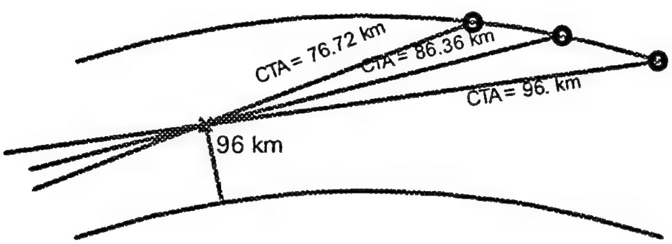


Figure 12. Variable Limb Path Geometry

Figure 13 is an example of the variable path multiple image capability.

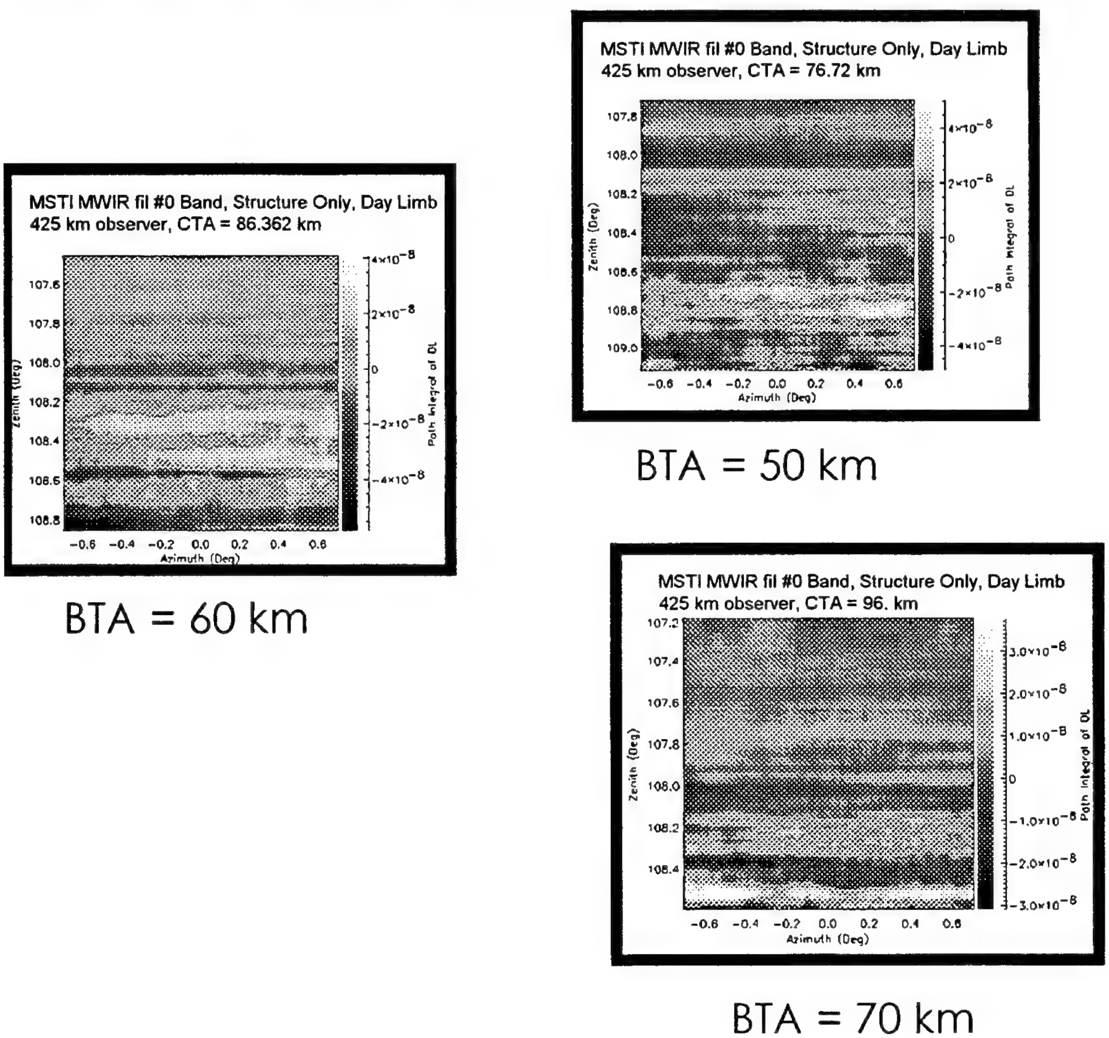


Figure 13. Synthetic Images; Variable Path ATH MSTI Scenes, Structure Only, MWIR, Filter 0, Day

2.5 RESULTS

A variety of digital filter synthesis methods may be employed to convert a series of Gaussian random numbers to correlated stochastic arrays. Perhaps the most frequently employed technique is the Fourier technique where Gaussian numbers are Fast Fourier Transformed, multiplied by a suitable filter function, and inverse Fast Fourier Transformed back to Cartesian space. In effect the one-dimensional process is represented by the simulated data $S(t)$ for the series t by: $S(t) = FFT^{-1}\left(\sqrt{\frac{P_{theor}(k_t)}{\Delta t}} \times FFT(\varepsilon_t)\right)$, where ε_t are the random numbers. In developing this report we performed the two-dimensional synthesis by Fourier transforming first in the vertical direction and then in the horizontal direction.

Using discrete Fourier transforms to estimate spectra, special care must be taken to avoid several well known pitfalls. The spacing between points must be kept small to avoid aliasing effects. Also the number of points simulated must be large so that numerical integration of the power spectrum in frequency space approximates the prescribed variance. On the other hand, since the method of AR synthesis provides the correct variance, a digital autoregressive (linear prediction) technique will avoid the FT variance problem. In applying the AR process, two new difficulties occur. First, one must decide how many AR coefficients to apply to achieve the desired statistics. Generally, the more coefficients that are used the better the desired *PSD* will be simulated. That is, an AR(p) process will exactly simulate the *ACF* to p lags. An increase in p translates into a better approximation of the remaining lags and therefore into less residual error of the *PSD*. In applying the AR process, the major difficulty is a need to overcome the filter relaxation time. If necessary this can be overcome by making several passes through the original white noise. The method has been described extensively in the literature[15,16] and by us (see references 4,5,6).

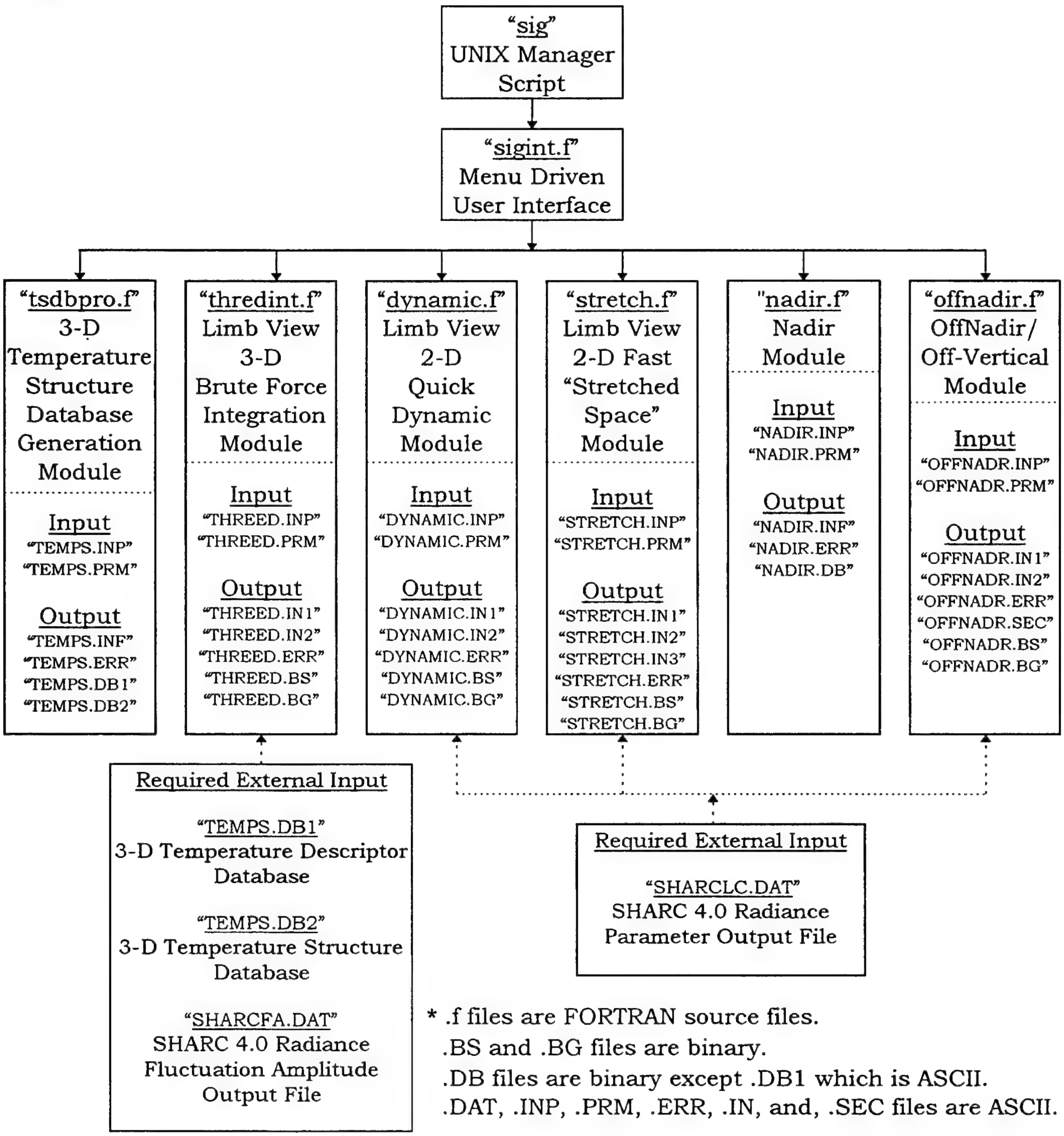
---

[15] Marple, S.L., (1987) *Digital Spectral Analysis with Applications*, Chapter 6, Prentice-Hall, New Jersey.

[16] Kay, Steven M., (1988) *Modern Spectral Estimation, Theory & Application*, Prentice-Hall, New Jersey.

3. PROCESSING PACKAGE OVERVIEW

The logical flow associated with the major components* of the overall SIG software package is indicated in Figure 14.



* .f files are FORTRAN source files.
.BS and .BG files are binary.
.DB files are binary except .DB1 which is ASCII.
.DAT, .INP, .PRM, .ERR, .IN, and, .SEC files are ASCII.

Figure 14. Major Components of the SIG Software Package

3.1 Silicon Graphics UNIX/FORTRAN Interface

The processing package was developed for the UNIX operating system. The package, modular in nature, consists of several software routines coded in FORTRAN-77. The processing applications are partitioned on the basis of specific scene generation approaches, (Limb View Brute Force 3-D Integration, Quick Dynamic 2-D Limb View, Fast "Stretched Space" Limb View, Nadir or Off-Nadir/Off Vertical approach). An optional application is the generation of the 3-D Temperature Structure Database. The package is automated on the basis of a primary manager UNIX script, "sig", and a FORTRAN program module, "sigint.f", with subroutines. These modules, accessed interactively, create UNIX batch scripts which run selected FORTRAN processing program modules in batch mode. The function and logical interactions of each of these modules are described in the following sections.

3.1.1 UNIX Manager Script - "sig"

The UNIX manager script, "sig", activates the FORTRAN program module, "sigint.f", which in turn, interactively determines which SIG application is to be run (refer to Section 3.1.2). Based on this choice, "sig", then creates a UNIX batch script which is executed in batch mode or in the background (refer to Section 3 1.3). An option not to execute is also available. The file name and code for this manager script are provided in Figure 15. Text, inserted in the script for clarification, is contained in < >.

<UNIX Manager Script "sig", which controls the SIG user interface.>

```
#!/bin/csh
#
# Decide which SHARC Image Generator program is to be run
sigint.out

# This script creates a script, which is executed
# in batch mode or in the background.
#
# Full path for file names may be used: e.g. /vol/09/sharc/cparsons
# set choice = `cat < /vol/09/sharc/cparsons/SIG.INP`
set choice = `cat < SIG.INP`

if($choice == 0)endif

if($choice == 1)then
  echo " UPON JOB COMPLETION, THE USER SHOULD EXAMINE THE sigtsdb.err"
  echo " FILE TO ENSURE THAT THE JOB HAS NOT ENCOUNTERED EXECUTION "
  echo " PROBLEMS "
  cat > sigtsdb.com << endtsdb.job
#!/bin/csh
#
# Have chosen to create a new 3-d temperature structure database
  echo " TEMPERATURE STRUCTURE DATABASE PROGRAM IS BEING COMPILED "
  setenv LM_LICENSE_FILE /appl/license/license.maxwell
```

```
  f77 tsdbpro.f -O2 -bytereclen -static -limsl -limslblas -mp -mips2 -o tsdbpro.out
  echo " JOB STARTED AT" \`date\`
  tsdbpro.out
  echo " JOB ENDED AT" \`date\`
endtsdb.job
chmod 700 sigtsdb.com
nohup sigtsdb.com >& sigtsdb.err &
endif

if($choice == 2)then
  echo " UPON JOB COMPLETION, THE USER SHOULD EXAMINE THE sig3din.err"
  echo " FILE TO ENSURE THAT THE JOB HAS NOT ENCOUNTERED EXECUTION "
  echo " PROBLEMS "
  cat > sig3din.com << end3din.job
#!/bin/csh
#
# Have chosen to use the 3-D integration to render scene
  echo " 3-D INTEGRATION PROGRAM IS BEING COMPILED "
  f77 thredint.f -O2 -bytereclen -mips2 -o thredint.out
  echo " JOB STARTED AT" \`date\`
  thredint.out
  echo " JOB ENDED AT" \`date\`
end3din.job
chmod 700 sig3din.com
nohup sig3din.com >& sig3din.err &
endif

if($choice == 3)then
  echo " UPON JOB COMPLETION, THE USER SHOULD EXAMINE THE sigdyn.err"
  echo " FILE TO ENSURE THAT THE JOB HAS NOT ENCOUNTERED EXECUTION "
  echo " PROBLEMS "
  cat > sigdyn.com << enddyn.job
#!/bin/csh
#
# Have chosen the quick dynamic approach to render scene
  echo " QUICK DYNAMIC PROGRAM IS BEING COMPILED "
  setenv LM_LICENSE_FILE /appl/license/license.maxwell
  f77 dynamic.f -O2 -bytereclen -static -limsl -limslblas -mp -mips2 -o dynamic.out
  echo " JOB STARTED AT" \`date\`
  dynamic.out
  echo " JOB ENDED AT" \`date\`
enddyn.job
chmod 700 sigdyn.com
nohup sigdyn.com >& sigdyn.err &
endif

if($choice == 4)then
  echo " UPON JOB COMPLETION, THE USER SHOULD EXAMINE THE sigstrs.err"
  echo " FILE TO ENSURE THAT THE JOB HAS NOT ENCOUNTERED EXECUTION "
  echo " PROBLEMS "
  cat > sigstrs.com << endstrs.job
#!/bin/csh
#
# Have chosen the stretched space approach to render scene
  echo " STRETCHED SPACE PROGRAM IS BEING COMPILED "
  setenv LM_LICENSE_FILE /appl/license/license.maxwell
  f77 stretch.f -O2 -static -limsl -limslblas -mp -mips2 -o stretch.out
  echo " JOB STARTED AT" \`date\`
  stretch.out
```

```
  echo " JOB ENDED AT" \`date\`
endstrs.job
chmod 700 sigstrs.com
nohup sigstrs.com >& sigstrs.err &
endif

if($choice == 5)then
  echo " UPON JOB COMPLETION, THE USER SHOULD EXAMINE THE signadr.err"
  echo " FILE TO ENSURE THAT THE JOB HAS NOT ENCOUNTERED EXECUTION "
  echo " PROBLEMS "
  cat > signadr.com << endnadr.job
#!/bin/csh
#
# Have chosen to use the nadir approach to produce radiance
# images
  echo " NADIR PROGRAM IS BEING COMPILED "
  setenv LM_LICENSE_FILE /appl/license/license.maxwell
  f77 nadir.f -O2 -bytereclen -static -limsl -limslblas -mp -mips2 -o nadir.out
  echo " JOB STARTED AT" \`date\`
  nadir.out
  echo " JOB ENDED AT" \`date\`
endnadr.job
chmod 700 signadr.com
nohup signadr.com >& signadr.err &
endif

if($choice == 6)then
  echo " UPON JOB COMPLETION, THE USER SHOULD EXAMINE THE sigoffn.err"
  echo " FILE TO ENSURE THAT THE JOB HAS NOT ENCOUNTERED EXECUTION "
  echo " PROBLEMS "
  cat > sigoffn.com << endoffn.job
#!/bin/csh
#
# Have chosen to use the off nadir approach to render scene
  echo " OFF NADIR PROGRAM IS BEING COMPILED "
  setenv LM_LICENSE_FILE /appl/license/license.maxwell
  f77 offnadir.f -O2 -mips2 -bytereclen -static -limsl -limslblas -mp -o offnadir.out
  echo " JOB STARTED AT" \`date\`
  offnadir.out
  echo " JOB ENDED AT" \`date\`
endoffn.job
chmod 700 sigoffn.com
nohup sigoffn.com >& sigoffn.err &
endif

# End of script
```

Figure 15. UNIX Manager Script, "sig", which controls the SIG user interface.

3.1.2 Interactive FORTRAN Program Module - "sigint.f"

The menu driven interactive FORTRAN program module, "sigint.f", is comprised of a main program module and six subroutines reflecting the six possible applications. Initially, the main program module queries the user concerning which processing

application to run. Based on the selection, control is passed on to the appropriate subroutine. The subroutine, via a menu-driven user interface and, for selected cases, information on existing databases (i.e., SHARC output), establishes the parameters which will be used in the particular application. The parameters are stored on two ASCII files (.INP & .PRM) which serve as input to the required follow-on processing program module. An option to use existing .INP & .PRM files as input is available. The creation of backup input menu files for archiving purposes is also an option. A value which determines whether or not the follow-on processing program module will be executed is then passed on to the main program module. The main program module stores a control flag which reflects the method to be used in the follow-on application in a file (SIG.INP) which is subsequently accessed by the UNIX script, "sig". Based on this flag, "sig", either terminates processing or creates a UNIX batch script which is executed in batch mode or in the background for the selected application (refer to Section 3.1.3).

3.1.3 UNIX Batch Scripts

The UNIX batch scripts run selected FORTRAN processing program modules in batch mode or in the background. Each of the six possible applications has a unique hardwired file name associated with its particular script. Each script has compilation and execution parameters unique to the program module application, the platform, and the operating system being used. The application, file name and code for each script are provided in Figures 16 through 21. Text, inserted in the scripts for clarification, is contained in < >.

A brief description of some of the arguments used in the Silicon Graphics UNIX workstation (SGI) f77 compilation statements follows.

-O2	Option to optimize the program run time
-bytereclen	With this option, record lengths used for unformatted direct I/O are specified as the number of bytes in a record. By default, record length specifications are interpreted as the number of 4-byte words in a record.
-static	This option causes all local variables to be statically allocated. Statically allocated local variables are initialized to zero and exist for the life of the program. This option is usually needed for programs ported from older systems, e.g. VMS, where all variables are statically allocated.
-mp	This switch enables the multiprocessing directives.
-mips2	This option is supported when compiling FORTRAN language source files.

It instructs the code generation phase to generate the SGI MIPS2 instructions whenever beneficial which allows the SGI math package to run faster. Code compiled and/or linked using the -mips2 option will not run on R2000/R3000 CPU based systems. Code compiled without the -mips option will run on systems based on the following SGI CPUs – R2000/R3000/R4000 – within the constraints of the operating system capability. If broad machine base compatibility is an issue, SGI recommends using the -mips2 option only when significant benefit is achieved on an R4000 CPU based system as compared to running the same program compiled without the -mips2 option on the same R4000 CPU based system.The double precision floating point load and store instructions require the data to be aligned on a double word boundary. A non-aligned access will cause the program to abort with a "bus error" message. This requirement may cause some programs that worked fine earlier, to fail when recompiled with the -mips2 option. This can happen in some FORTRAN programs that have common blocks with an odd number of integer values followed by double precision data.

-o output — Names the final output file output. If this option is not used, the default file is a.out.

-limsl — Links the standard IMSL library to the program compilation. This library contains math applications, statistical analysis and special functions.

-limslblas — Links the IMSLBLAS library to the program compilation. This library provides extensive use of basic linear algebraic subprograms, BLAS, that assure uniformity and stability in vector/matrix operations.

<Application (3-D Temperature Structure Database Generation)>

<File Name: "sigtsdb.com">

```
#!/bin/csh
#
# Have chosen to create a new 3-d temperature structure database
  echo " TEMPERATURE STRUCTURE DATABASE PROGRAM IS BEING COMPILED "
  setenv LM_LICENSE_FILE /appl/imsl/license.maxwell
  f77 tsdbpro.f -O2 -bytereclen -static -limsl -limslblas -mp -mips2 -o tsdbpro.out
  echo " JOB STARTED AT" `date`
  tsdbpro.out
  echo " JOB ENDED AT" `date`
```

Figure 16. UNIX Batch Script, "sigtsdb.com", which executes the 3-D Temperature Structure Database Generation program module.

<Application (Limb View Brute Force 3-D Integration Approach)>

<File Name: "sig3din.com">

```
#!/bin/csh
#
# Have chosen to use the 3-D integration to render scene
  echo " 3-D INTEGRATION PROGRAM IS BEING COMPILED "
  f77 thredint.f -O2 -bytereclen -mips2 -o thredint.out
  echo " JOB STARTED AT" `date`
  thredint.out
  echo " JOB ENDED AT" `date`
```

Figure 17. UNIX Batch Script, "sig3din.com", which executes the Limb View Brute Force 3-D Integration program module.

<Application (Quick Dynamic 2-D Limb View Approach)>

<File Name: "sigdyn.com">

```
#!/bin/csh
#
# Have chosen the quick dynamic approach to render scene
  echo " QUICK DYNAMIC PROGRAM IS BEING COMPILED "
  setenv LM_LICENSE_FILE /appl/license/license.maxwell
  f77 dynamic.f -O2 -bytereclen -static -limsl -limslblas -mp -mips2 -o dynamic.out
  echo " JOB STARTED AT" `date`
  dynamic.out
  echo " JOB ENDED AT" `date`
```

Figure 18. UNIX Batch Script, "sigdyn.com", which executes the Quick Dynamic 2-D Limb View program module.

<Application (Fast "Stretched Space" 2-D Limb View Approach)>

<File Name: "sigstrs.com">

```
#!/bin/csh
#
# Have chosen the stretched space approach to render scene
  echo " STRETCHED SPACE PROGRAM IS BEING COMPILED "
  setenv LM_LICENSE_FILE /appl/license/license.maxwell
  f77 stretch.f -O2 -static -limsl -limslblas -mp -mips2 -o stretch.out
  echo " JOB STARTED AT" `date`
  stretch.out
  echo " JOB ENDED AT" `date`
```

Figure 19. UNIX Batch Script, "sigstrs.com", which executes the Fast "Stretched Space" 2-D Limb View program module.

<Application (Nadir Approach)>

<File Name: "signadir.com">

```
#!/bin/csh
#
# Have chosen to use the nadir approach to produce radiance
# images
  echo " NADIR PROGRAM IS BEING COMPILED "
  setenv LM_LICENSE_FILE /appl/imsl/license.maxwell
  f77 nadir.f -O2 -bytereclen -static -limsl -limslblas -mp -mips2 -o nadir.out
  echo " JOB STARTED AT" `date`
  nadir.out
  echo " JOB ENDED AT" `date`
```

Figure 20. UNIX Batch Script, "signadir.com", which executes the Nadir program module.

<Application (Off-Nadir/Off -Vertical Approach)>

<File Name: "sigoffn.com">

```
#!/bin/csh
#
# Have chosen to use the off nadir approach to render scene
  echo " OFF NADIR PROGRAM IS BEING COMPILED "
  setenv LM_LICENSE_FILE /appl/license/license.maxwell
  f77 offnadir.f -O2 -mips2 -bytereclen -static -limsl -limslblas -mp -o offnadir.out
  echo " JOB STARTED AT" `date`
  offnadir.out
  echo " JOB ENDED AT" `date`
```

Figure 21. UNIX Batch Script, "sigoffn.com", which executes the Off-Nadir/Off-Vertical program module.

3.2 FORTRAN Processing Modules

A self contained FORTRAN processing module is provided for each application. Individual compilation statements containing the file name of each module are exhibited in the UNIX batch scripts (refer to Section 3.1.3). Each submission results in the particular processing module being recompiled to reflect the status of the parameters contained in the latest .PRM file via INCLUDE statements. For each submission, parameters contained in the latest .INP file are input to the particular module via FORTRAN read statements. The primary output databases (.DB) generated by each module are written in binary format to save storage space and minimize

access time. The binary format is essential since these database files are used for follow-on analysis and the generation of displays. Error, informational, and run time output files generated by the modules are written in ASCII format to facilitate the review process. An error file (.ERR) containing error and warning statements encountered during module execution is generated for each run. An error message during execution is usually considered fatal, and execution will stop after the error message is written to the error file. The user should monitor the error file after each run to insure success. An informational file (.INF), generated during module execution, contains results which serve to inform the user of the integrity of the computations being performed. The user should review these results whenever necessary to insure that the calculations were properly performed. A run time file (.SEC) containing module run times is generated for selected applications.

A functional description along with algorithms and special techniques for each module follows.

3.2.1 3-D Temperature Structure Database Program Module - "tsdbpro.f"

Definitions and notations:

FFT	Fast Fourier transform
PSD	Power spectral density.
LOS	Line-of-sight.
X-LOS	Component in the LOS direction for a constant altitude.
Y-LOS	Component transverse to LOS direction for a constant altitude.
Z-LOS	Component in the vertical direction along earth centered rays.
N_{vh}	Number of values along a given vertical ray in the simulated data base. At each vertical value, a horizontal sheet is simulated by the program module. N_{vh} is an input value.
N_{sh}	Number of horizontal sheets used to overcome relaxation (in effect, the number of iterations to start the simulation process). N_{sh} is an input value.
p_v	Order of AR process which is the number of autoregressive (AR) coefficients in the filter used to simulate the vertical PSD. p_v is an input value.

This program module constructs one realization of the non stationary stochastic fractional-temperature fluctuations (DT/T) in the simulated three-dimensional atmosphere. The resulting database, consisting of a three-dimensional array, is used by the 3-D integration scene-generation module. The DT/T values are generated from a model of the PSDs in the earth centered horizontal tangent planes and vertical direction. The database is equally spaced in distance along the component of the LOS and for a given Z is equally spaced in distance along the X and Y components of the LOS. The components X-LOS, Y-LOS, and Z-LOS are generally referred to in this

writeup as the LOS, transverse and vertical directions, respectively, (refer to Figure 2). The components are assumed orthogonal to each other at all points of the database. These assumptions, although contradictory for a spherical earth, are good approximations as long as the length of the Y axis used in the calculations is significantly less than the radius of the earth.

Initially, horizontal sheets of Gaussian-distributed variates with unit standard deviation are simulated. The total number of horizontal sheets simulated is the sum of the number of values along a given vertical ray (N_{vh}) and the value used to overcome relaxation of the recursive filters (N_{sh}). Next, variations in the vertical direction are filtered onto vertical rays which pass through the ensemble of sheets. A recursive filter is applied to each ray: the filter correlates values sequentially from low altitudes to high, by using previously-filtered values along with the current value to derive a predicted estimate for the altitude under consideration. The number of vertical autoregression coefficients (p_v) of this filter is an input parameter to the program module. Generally, the quality of the simulation improves as the number of coefficients is increased. The program module's default value ($p_v = 6$) has been adequate for the (nonexhaustive) simulations performed. The autoregressive filters keep the variance at unity. Caution should be exercised in increasing p_v since the mathematics used to find the autoregressive coefficients assumes stationarity of the PSD. This approximation is valid only over short distances along a vertical ray.

After all the points in the database have been vertically correlated by the above process, each sheet is correlated in the X and Y directions. FFTs are applied in the Y-LOS direction. The results of these FFTs are then used as input for FFTs in the X-LOS direction (simulating a two-dimensional FFT at a fixed altitude). The desired PSD, having the desired standard deviation, is then applied to the resultant Fourier coefficients. Finally, an inverse FFT of these modified Fourier coefficients is applied, resulting in the intended simulation for each sheet being processed.

One complication of the vertical-autoregressive procedure is that the filter used to apply the desired PSD in the Z-LOS direction has a finite relaxation time. That is, the desired PSD for a given altitude can only be obtained if the values before that altitude already approximately contain the desired autocorrelation (or PSD). To allow for filter relaxation, the program module constructs the additional set of (N_{sh}) horizontal sheets of normally distributed data points, for the lowest altitude in the database. The filter is then applied through these additional horizontal sheets. The last p_v values of this initialization process are used as starting values for the horizontal sheets included in the database. As long as N_{sh} is on the order of N_{vh}, the run time of the program module is not significantly affected by the processing required to initialize the filter. As N_{sh} increases, accuracy of the initialization improves. The user can adjust N_{sh} accordingly; its default value has been set to 51.

3.2.2 Limb View Brute Force 3-D Integration Program Module - "thredint.f"

Definitions and notations:

bore	Line perpendicular to the sensor from the center of the sensor to the center of the scene.
DT/T	Database of fractional temperature fluctuation ($W/cm^2 \cdot ster \cdot {}^0K \cdot km$), used in the simulation.
F_A	Fluctuation amplitude.
P	Particular point on the line integral from a pixel on the sensor.
R_P	Intermediate radiance fluctuation assigned to P.
T_P	Background temperature at P.
T_D	Fractional temperature fluctuation at the point in the DT/T database which is closest to P.
Z_A	Zenith angle (degrees).
S_R	Slant range (km).

This program module uses numerical integration to estimate the non-stationary radiance fluctuations seen by a sensor looking through the atmosphere. A line integral is taken along the path seen by each pixel of the sensor. The contributions to the line integral are the product of the local radiance responses to temperature calculated along the path and the temperature fluctuations. These values are obtained from two input files, the 3-D temperature structure database file and the SHARC 4.0 radiance fluctuation amplitude output file, "SHARCFA.DAT". The 3-D temperature structure database consists of a particular realization from a statistical model of the fractional temperature fluctuation (DT/T) versus a background model of the temperature. The SHARC input file contains a set of fluctuation amplitudes (F_A)s which are used to multiply the temperature to get radiance for the line integrals.

The program module has the option of generating multiple scenes. Each scene is generated for a particular bore zenith angle. The center ray of each scene intersects at a common altitude (refer to Figure 12). The common altitude is set as the bore tangent altitude for that scene having the smallest bore zenith angle.

A running sum of each of the line integrals is maintained. The running sums are updated between vertical sheets in the Y-Z plane of the DT/T database. Thus, all the calculations needed between two vertical sheets are performed before considering the effects of the next vertical sheet. This results in only two vertical sheets of the DT/T database in core at one time.

The line integrals between two vertical sheets are estimated, as follows. First, for one of the line integral paths, we find the positions at which this path intersects the two sheets. Second, a straight line drawn between the two points is used as an approximation of the path between the two sheets. This is an approximation since the line is actually not straight due to the earth's spherical shape.

The LOS segment between two vertical sheets is divided into equal increments such that the change in the Y-LOS and Z-LOS directions over each increment is less than their corresponding X-LOS and Y-LOS spacing in the DT/T database.

The computation of the line integrals is approximated by a trapezoidal rule. The integrands are (R_p = DT x F_A). Here, DT = T_D x T_P where T_P is the background temperature at point P and T_D is the fractional temperature fluctuation from the DT/T database at the point in the database closest to P. F_A is found from the SHARC 4.0 output file, "SHARCFA.DAT". We obtain T_p and F_A at the needed location by linear interpolation on the values from "SHARCFA.DAT". Alternatively, T_P is found from the "U.S. Standard Atmosphere" model as programmed in subroutine "STDTEMP". The linear interpolation is performed on zenith angle. The interpolated results are then re-interpolated on slant range along the LOS. These interpolations are based on tables of T_P and F_A as functions of increasing LOS distance.

For selected parameters, new tables (to be used for interpolation) are derived from the original tables from the SHARC 4.0 output file as shown in Section 4.2.1.5. Subsequently, linear interpolation is performed on the new tables to calculate F_A and T_P at a particular S_R and Z_A where S_R is the slant range or the distance measured along a ray from the sensor starting at the point the ray enters the atmosphere and Z_A is the zenith angle of this ray. For each new table, a zenith angle is derived from the tangent altitude of the corresponding original table. In the original tables, F_A appears in the second column for a segment, T_P, in the sixth column, and S_R in the fifth column. Each of the original tables have values of F_A and T_P for a range of S_R values. Thus, for the k^{th} segment of the j^{th} table, $F_A(j,k)$ and $T_P(j,k)$ are assigned between slant ranges, $S_R(j,k)$ and $S_R(j,k-1)$ where $S_R(j,0) = 0$. Here, k = 1, 2, 3,..., the number of segments in the k^{th} table and j = 1, 2, 3,..., the number of tables.This is a staircase model for F_A and T_P as a function of S_R. In order to perform linear interpolation, the new table is assumed to be a piece-wise linear model for F_A and T_P as a function of a new slant range S'_R.

The new tabular parameters (F'_A, T'_P,and S'_R) are derived from the original tables as follows. In the new tables, an additional segment (k = 0) is added where, $F'_A(j,0) = F_A(j,1)$, $T'_P(j,0) = T_P(j,1)$ and, $S'_R(j,0) = 0$. For k > 0, $F'_A(j,k) = F_A(j,k)$, $T'_P(j,k) = T_P(j,k)$ and $S'_R(j,k) = (S_R(j,k)+S_R(j,k-1))/2$. The following table lists the parameters derived from the original table for the 250 km tangent altitude case.

F'_A	T'_P	S'_R
-0.15565E-18	0.9918E+03	0.00000
-0.15565E-18	0.9918E+03	21.58510
-0.19843E-18	0.9907E+03	64.75535
-0.28455E-18	0.9895E+03	110.81305
-0.40469E-18	0.9882E+03	159.75821
-0.55880E-18	0.9867E+03	213.22696
-0.77225E-18	0.9850E+03	271.21924
-0.10449E-17	0.9831E+03	337.96082
-0.14208E-17	0.9809E+03	413.45160
-0.17563E-17	0.9792E+03	487.60022
-0.19478E-17	0.9782E+03	560.40674
-0.21392E-17	0.9770E+03	633.21326
-0.24664E-17	0.9760E+03	706.01978
-0.27936E-17	0.9748E+03	778.82629
-0.27936E-17	0.9748E+03	851.63281
-0.24664E-17	0.9760E+03	924.43933
-0.21392E-17	0.9770E+03	997.24585
-0.19478E-17	0.9782E+03	1070.05225
-0.17563E-17	0.9792E+03	1142.85889
-0.14208E-17	0.9809E+03	1217.00757
-0.10449E-17	0.9831E+03	1292.49829
-0.77225E-18	0.9850E+03	1359.23975
-0.55880E-18	0.9867E+03	1417.23218
-0.40469E-18	0.9882E+03	1470.70093
-0.28455E-18	0.9895E+03	1519.64600
-0.19843E-18	0.9907E+03	1565.70374
-0.15565E-18	0.9918E+03	1608.87390

Table 3. Interpolation Table Derived From SHARC 4.0 Output (Tangent Altitude = 250 km) (refer to Section 4.2.1.5).

Values of F_A and T_P for a given S'_R and Z_A required by the program module are derived by linear interpolation on the new tables. In the event that Z_A falls outside the range of the tabular values, a 1% extension of the length of the appropriate end segment is allowed to accommodate extrapolation. Extrapolation, however, is not allowed when values of S'_R fall outside the range of the tabular values. If any additional extrapolation is required, F_A and T_P are set to zero.

The slant range that is used for interpolating values of T_P and F_A is the distance along the bore LOS. However, the LOS being followed usually is not the bore. The approximation of using the bore distance speeds up the calculations and is justified by the fact that the DT/T database has an inherent, but small, inaccuracy in assuming equal spacing in the X-LOS direction. Consequently, some approximation is necessary to match the DT/T and the SHARC 4.0 output.

If the altitude of the line integral is outside the limits of the DT/T database, T_D is set to 0. If the altitude is acceptable but the X-LOS and/or the Y-LOS value is outside the DT/T database, reflection of the database is assumed to define the position in the DT/T database. That is, the first point in either the X-LOS or Y-LOS direction is assumed to follow the last point of the DT/T database in that direction. Thus, the last point of the DT/T database immediately precedes the first point of the reflected database for that direction.

3.2.3 Quick Dynamic 2-D Limb View Program Module - "dynamic.f"

Definitions and notations:

Z_A	Zenith angle (degrees).
L_{ch}	Horizontal radiance correlation angle (radians).
L_{cv}	Vertical radiance correlation angle (radians).
S_h	Spectral index of the PSD in the horizontal direction.
S_v	Spectral index of the PSD in the vertical direction.
STD	Relative standard deviation of the scene.
N_v	Number of vertical pixels in the simulated sensor (or scene), (an input value).
N_{rv}	Number of points used to relax the filter that simulates the PSD of the scene in the vertical direction, (an input value).
N_v'	Number of points used to simulate the scene in the vertical direction. $N_v' = N_v + N_{rv}$.
N_t	Number of transverse pixels in the simulated sensor (or scene), (an input value).
N_t'	Number of points used in FFT to simulate the scene in the transverse direction, (an input value). $N_t' \geq N_t$.
p_v	Order of AR process which is the number of autoregressive (AR) coefficients in the filter used to simulate the vertical PSD. p_v is an input value.

This program module simulates a radiance scene using radiance, statistical and spectral estimates contained in the SHARC 4.0 radiance parameter output file, "SHARCLC.DAT". These quantities which are functions of zenith angle (Z_A) include the horizontal (L_{ch}) and vertical (L_{cv}) radiance correlation angles, the log-log slopes (indices) of the power spectral density (PSD) in the horizontal (S_h) and vertical (S_v) directions and the relative standard deviation (STD). The user would invoke this option as an alternative to the 3-D approach.

The final simulated radiance scene consists of (N_v) pixels in the Z-LOS (or vertical) direction and (N_t) pixels in the Y-LOS (or transverse) direction. N_v and N_t are input parameters. The bore zenith angle of the simulated scene is derived from the bore tangent altitude, an input parameter. Actually, (N_v') points are used to simulate the scene in the Z-LOS direction and (N_t') points in the Y-LOS direction. N_t' is an input value and is greater than or equal to N_t. N_v' is greater than N_v. $N_v' = N_v + N_{rv}$ where N_{rv}, an input value, is the number of extra vertical points used to overcome the relaxation time of the AR filter which forms the desired PSD in the Z-LOS direction. The process is described below.

Initially, an ($N_v' \times N_t'$) array is filled with Gaussian random numbers having a mean of zero and a variance of one. These values form a rectangular grid that can be viewed as N_v' Y-LOS lines of N_t' equally spaced values or N_t' Z-LOS lines of N_v' equally spaced values. The Y-LOS and Z-LOS spacings are defined from the angular instantaneous-field-of-view. The first N_{rv} values of the Z-LOS lines of data are assigned the values of L_{cv} and S_v associated with the largest zenith angle to be simulated. The remainder of each Z-LOS line is assigned the L_{cv} and S_v values in descending Z_A order. The correlations in the Z-LOS direction are then filtered onto these Z-LOS lines by applying AR (p_v) coefficients to each of the Z-LOS lines. The filter coefficients at Z_A are calculated such that the AR PSD has the specified L_{cv} and S_v values. Generally, the more coefficients that are used, the better the desired PSD will be simulated. The default value of $p_v = 6$ was sufficient for the cases tried. Caution should be exercised in increasing p_v since the mathematics used to find the autoregressive coefficients assumes local stationarity of the PSD. This approximation is valid only over short distances along a vertical ray.

The AR filter approximates the PSD at each Z_A from a weighted sum of filtered values immediately preceding Z_A and the original value at Z_A. The first N_{rv} values are used only to overcome the relaxation time of the filter and are discarded after filtering. This allows the program module to have only p+1 values of the Z-LOS line in core while the first N_{rv} values are being calculated. As N_{rv} increases, the relaxation problem diminishes. Further, as long as N_{rv} is the same magnitude as N_v, its value does not significantly affect the run time of the program module. N_{rv} can be adjusted, accordingly. The default value for N_{rv} has been set to 51. After discarding N_{rv} values of each filtered Z-LOS line, there remains N_t' Z-LOS lines of N_v points. At this stage, the program module takes a 1-D FFT of the N_t' values at each Z_A. The resultant values are then multiplied by quantities that apply the desired Y-LOS PSD filter. These quantities are calculated to include the desired standard deviation at Z_A. The specified Y-LOS PSD is determined by the values of L_{ch}, S_h and STD at Z_A using a Wittwer-Kilb (W-K) model. The specified PSD amplitudes are applied at those discrete frequencies generated by the FFT. This leads to an approximation error because the PSD is continuous in frequency and the FFT is evaluated at a set of discrete frequencies. As N_t' increases, the spacing between frequencies (frequency resolution) used to approximate the continuous PSD become smaller. Larger N_t' results in a more accurate approximation and is why N_t' is allowed to be greater than or equal to N_t. The execution time of this phase of the program module increases faster than the quantity, N_t', a consideration when setting the value of N_t'. After the above processing, the first N_t Y-LOS values at each of the N_v values of Z_A constitute that part of the simulated scene.

3.2.4 Fast "Stretched Space" 2-D Limb View Program Module - "stretch.f"

Definitions and notations:

IFOV	Instantaneous-field-of-view (degrees).
Z_A	Zenith angle (degrees).
Z_{Amin}	Smallest zenith angle used for simulation.
Z_{Amax}	Largest zenith angle used for simulation.
L_{ch}	Horizontal radiance correlation angle (radians).
L_{cv}	Vertical radiance correlation angle (radians).
STD	Relative standard deviation of the scene.
S_{hp}	Index of the horizontal 1-D PSD, (an input value).
S_{vp}	Index of the vertical 1-D PSD, (an input value).
L_{cvs}	Vertical radiance correlation angle in "stretched space". This value is a constant.
p_v	Order of AR process which is the number of autoregressive (AR) coefficients in the filter used to simulate the vertical PSD. p_v is an input value.
N_t	Number of transverse pixels in simulated sensor (or scene). N_t is an input value.
N_v	Number of vertical pixels in simulated sensor (or scene). N_v is an input value.
N_{rv}	Number of values used to relax the filter which simulates the PSD of the scene in the vertical direction. If FFTs are used to simulate the PSD in the vertical direction, $N_{rv} = 0$. N_{rv} is an input value.
N_v'	Number of points used to simulate scene in the vertical direction. $N_v' = N_v + N_{rv}$.
$P_v(i)$	Set of N_v equally spaced "stretched space" points between Z_{Amax} and Z_{Amin} for i=1,2,3,..., N_v. The $P_v(i)$ are vertical points.
$P_v'(i)$	Position of the $P_v(i)$ points in the original space.

This program module simulates a radiance scene using radiance, statistical and spectral estimates contained in the SHARC 4.0 radiance parameter output file, "SHARCLC.DAT". These quantities which are functions of zenith angle (Z_A) include the horizontal (L_{ch}) and vertical (L_{cv}) radiance correlation angles and the relative standard deviation (STD). The user would invoke this option as an alternative to the 3-D approaches.

The final simulated radiance scene consists of (N_v) pixels in the Z-LOS (or vertical) direction and (N_t) pixels in the Y-LOS (or transverse) direction. N_v and N_t are input parameters. The bore zenith angle of the simulated scene is derived from the bore tangent altitude, an input parameter. Actually, (N_v') points are used to simulate the scene in the Z-LOS direction where N_v' is greater than or equal to N_v. When a filter (as described below) is used to simulate the power spectral density (PSD) in the Z-LOS

direction, $N_v' = N_v + N_{rv}$ where N_{rv} is an input value used to overcome the relaxation time of the filter. Otherwise, $N_v' = N_v$.

The simulation is performed in a "stretched space". In this space, the vertical radiance correlation angle (L_{cvs}) is a constant over the zenith angles considered. A set of N_v equally spaced points ($P_v(i)$) are assumed in "stretched space" between the largest zenith angle (Z_{Amax}) and the smallest zenith angle (Z_{Amin}) used for the simulation. It is further assumed that the range of these points is the same as the range of the original Z_A points to be simulated. The vertical radiance correlation angle, L_{cvs}, and the Z_A values in the original space corresponding to the $P_v(i)$ equally spaced values in "stretched space" are derived below. Linear interpolation is used to find the values at the zenith position of points simulated in the Z-LOS direction from the values simulated at the position of the $P_v(i)$ points in the original space ($P_v'(i)$).

The calculation of the vertical radiance correlation angle in "stretched space", L_{cvs}, and the position of the $P_v(i)$ points in the original space, $P_v'(i)$, is done as follows. Define $I(Z_A)$ as the integral of $-(1/L_{cv})$ from Z_{Amax} to a zenith angle, Z_A, less than Z_{Amax}. The integral is a positive quantity. Then, $L_{cvs} = 1/((Z_{Amax} - Z_{Amin})\cdot I(Z_{Amin}))$. Further, the i^{th} point of $P_v'(i)$ is the value of Z_A for which $I(Z_A)=(i-1)\cdot I(Z_{Amin})/(N_v - 1)$ for $i=1,2,3,\ldots, N_v$. This leads to the following technique to estimate L_{cvs} and $P_v'(i)$. The integrals, $I(Z_A)$, are estimated by applying a trapezoidal rule to values of $-(1/L_{cv})$. The values of $-1/L_{cv}$ are found by linear interpolation using the vertical radiance correlation angles in the SHARC 4.0 radiance parameter output file, "SHARCLC.DAT". The integrals, $I(Z_A)$, are calculated for 10000 equally spaced values of Z_A between Z_{Amax} and Z_{Amin}. The value of L_{cvs} is then calculated from the formula, $L_{cvs} = 1/((Z_{Amax} - Z_{Amin})\cdot I(Z_{Amin}))$. Values of $P_v'(i)$ are then found by using linear interpolation on the table of 10000 equally spaced Z_A values versus $I(Z_A)$. Thus, the Z_A values of $P_v'(i)$ are determined from the expression, $I(Z_A)=(i-1)\cdot I(Z_{Amin})/(N_v - 1)$ for $i=1,2,3,\ldots, N_v$.

After this process, N_v' transverse lines, each with N_t normally distributed data points, are simulated. The lines are equally spaced in the $P_v(i)$ (or vertical) direction of the "stretched space" such that their average zenith spacing is the instantaneous-field-of-view (IFOV) in the Z-LOS direction. This forms Z-LOS lines which are also equally spaced in the IFOV in this "stretched space". The variance simulated at this point is unity. If an AR filter is used to create the PSD in the Z-LOS direction, N_{rv} values are added to the beginning of each line of data in this direction, thus ($N_v' = N_v + N_{rv}$). The variation in the Z-LOS direction is then filtered onto these Z-LOS lines. One possible method to form the desired PSD or autocorrelation to the Z-LOS lines is to apply a recursive filter with (p_v) autoregressive (AR) coefficients. This filter simulates the Z-LOS PSD or autocorrelation at each of the Z-LOS lines. Generally, the more coefficients that are used the better the desired PSD will be simulated. The default value of $p_v = 6$ was sufficient for the cases tried. Caution should be exercised in increasing p_v since the mathematics used to find the autoregressive coefficients

assumes local stationarity of the PSD. This approximation is valid only over short distances along a vertical ray. Alternatively, the PSD can be applied to an FFT of each Z-LOS line.

The AR filter approximates the PSD of the Wittwer-Kilb (W-K) model which uses the radiance correlation angle, L_{cvs}, and the spectral index of the Z-LOS 1-D PSD (S_{vp}), an input value, and has a standard deviation of 1. The filtering is a weighted sum of filtered values immediately preceding Z_A and the original value at Z_A. The first N_{rv} values are used only to overcome the relaxation time of the filter. After filtering, the first N_{rv} values are discarded. This allows the program module to maintain only p_v+1 values of the line in core while the first N_{rv} values are being calculated. As N_{rv} increases, the relaxation problem diminishes. Further, as long as N_{rv} is the same magnitude as N_v its value does not significantly affect the run time of the program module. The value of N_{rv} can be adjusted accordingly. The default value for N_{rv} has been set to 51. After discarding N_{rv} values of each filtered zenith line, N_t zenith lines of N_v points remain. An input switch determines whether AR filtering or FFTs is used to apply the desired PSD in the vertical (or $P_v(i)$) direction. In the case that the PSD in the Z-LOS direction is applied using an FFT, an FFT of the N_v values for each Z-LOS line is taken. The resultant coefficients are then multiplied by Fourier coefficient values that apply the desired PSD with radiance correlation angle L_{cvs} and spectral index S_{vp}. The desired PSD is applied at the discrete frequencies generated by the PSD. This process leads to an approximation error since a continuous curve appears at a set of discrete points. As the value of N_v increases, the spacing between frequencies (frequency resolution) used to approximate the continuous PSD become smaller. Larger N_v results in a more accurate approximation. An inverse FFT then provides data with the desired PSD in the Z-LOS direction with variance still equal to unity.

At this stage, N_t partially filtered points in "stretched space" for N_v $P_v(i)$ values have been computed. The desired Y-LOS PSDs are now applied to the N_v Y-LOS lines. The PSD is determined by using a W-K model with radiance correlation angles L_{ch} from the SHARC 4.0 radiance parameter output file, "SHARCLC.DAT", and spectral index (S_{hp}), an input value. The altitude of Z_A at which the PSD is applied is found from the values of $P_v'(i)$. Linear interpolation on the SHARC 4.0 output is used to find the L_{ch} values at each of the $P_v'(i)$ positions.

The techniques used to apply the Y-LOS PSD are the same as those used to apply the PSD to a Z-LOS line, as described above, with two differences. The first difference is that the result is multiplied by the desired standard deviation. The second difference concerns the problem of overcoming the relaxation time, if AR filtering is used, to apply the PSD. The solution to this problem is to use a method which filters each Y-LOS line of data twice. That is, the filter is first applied to a Y-LOS line. Then, assuming the last p_v values of the filtered result are the initial values for the actual filtering, the filter is applied a second time.

The above procedure results in a set of data with the desired PSD in "stretched space". A return to normal space is achieved by linear interpolation on the results to find values at $P_v'(i)$. These interpolated values are the desired synthetic non stationary radiance fluctuations.

3.2.5 Nadir Program Module - "nadir.f"

Definitions and notations:

L_c	Radiance correlation angle (radians).
S	Spectral index, (an input value).
W-K	Wittwer-Kilb model of the PSD and autocorrelation given the radiance correlation angle, standard deviation, and spectral index of the model.
N_X'	Number of points in FFT used to simulate the scene in the X-LOS direction, (an input value).
N_X	Number of pixels in the simulated sensor (or scene) in the X-LOS direction, (an input value). N_X is a subset of the N_X' points.
N_Y'	Number of points in FFT used to simulate the scene in the Y-LOS direction, (an input value).
N_Y	Number of pixels in the simulated sensor (or scene) in the Y-LOS direction, (an input value). N_Y is a subset of the N_Y' points.
$IFOV_X$	Instantaneous-field-of-view in the X-LOS direction (degrees), (an input value).
$IFOV_Y$	Instantaneous-field-of-view in the Y-LOS direction (degrees), (an input value).
STD	Relative standard deviation of the simulated scene, (an input value).
A_s	Altitude of the scene, (an input value).
Δ_X	Spacing at A_s covered by $IFOV_X$.
Δ_Y	Spacing at A_s covered by $IFOV_Y$.
G(i,j)	Set of uncorrelated Gaussian values with standard deviation = 1 and mean = 0, for i=1,2,3,..., N_X' and j=1,2,3,..., N_Y'.
$G_1(i,j)$	Result of applying a 1-D FFT to each j value of G(i,j) for i=1,2,3,..., N_X'.
$G_2(i,j)$	Result of applying a 1-D FFT to each i value of $G_1(i,j)$ for j=1,2,3,..., N_Y'.
$G_3(i,j)$	Result of multiplying $G_2(i,j)$ by PSD filter amplitudes to simulate the W-K model.
$G_4(i,j)$	Scene of (N_X' x N_Y') simulated points.
$G_5(i,j)$	Subset of $G_4(i,j)$ which is a scene of (N_X x N_Y) simulated pixels.

This program module simulates a radiance scene in the nadir (straight down) direction. It is assumed that the sensor is at a particular altitude and looks down to

the scene with an altitude (A_s). A linear conversion factor is used in converting from instantaneous-field-of-view to distance.

A final radiance scene of (N_X) pixels in the X-LOS direction and (N_Y) pixels in the Y-LOS direction, is simulated. To create this scene, a 2-D Wittwer-Kilb (W-K) model is applied to a set of ($N_X' \times N_Y'$) random points. N_X' and N_Y' are input parameters. N_X is a subset of the N_X' points and N_Y is a subset of the N_Y' points. N_X and N_Y are also input parameters.

Initially, N_X' points are simulated in the X-LOS direction and N_Y' points in the Y-LOS direction. These ($N_X' \times N_Y'$) points are from an uncorrelated Gaussian distribution with variance unity. Call this initial data set, G(i,j), where, i=1,2,3,..., N_X' and j=1,2,3,..., N_Y'. A 2-D FFT is then applied to the 2-D array. The 2-D FFT is accomplished by first applying 1-D FFTs to the N_Y' lines of N_X' points of G(i,j) to form (G_1(i,j)). This is followed by applying 1-D FFTs to the N_X' lines of N_Y' points of G_1(i,j) to form G_2(i,j). G_2(i,j) is the desired 2-D FFT. Using a 2-D W-K model, G_2(i,j) is multiplied by quantities to modify the values at each (i,j) to simulate the W-K distribution and form G_3(i,j). The W-K model is continuous with radiance correlation angle (L_c), standard deviation (STD), and spectral index (S), all of which are input values. G_2(i,j) is defined at ($N_X' \times N_Y'$) discrete frequencies. As N_X' and N_Y' increase, the closer together the simulated frequencies become, and the more accurately G_3(i,j) approximates the W-K model. For this reason, the ($N_X' \times N_Y'$) points simulated can be greater than or equal to the ($N_X \times N_Y$) pixels simulated. Next an inverse 2-D FFT of G_3(i,j) creates a scene of ($N_X' \times N_Y'$) points (G_4(i,j)). Lastly, G_5(i,j), the desired simulated scene of ($N_X \times N_Y$) pixels and a subset of G_4(i,j), is created.

3.2.6 Off-Nadir/Off-Vertical Program Module - "offnadir.f"

Definitions and notations:

Z_A	Zenith angle (degrees).
L_{ch}	Horizontal radiance correlation angle (radians).
L_{cv}	Vertical radiance correlation angle (radians).
S_h	Spectral index of the PSD in the horizontal direction.
S_v	Spectral index of the PSD in the vertical direction.
STD	Relative standard deviation of the scene.
W-K	Wittwer-Kilb model of the PSD and autocorrelation given the radiance correlation angle, standard deviation, and spectral index of the model.
N_v	Number of pixels in simulated sensor (or scene) in the vertical direction, (an input value).

N_{rv}	Number of values used to relax the filter which simulates the scene in the vertical direction, (an input value).
N_v'	Number of points used to simulate scene in the vertical direction. $N_v' = N_v + N_{rv}$.
p_v	Order of AR process which is the number of autoregressive (AR) coefficients in the filter used to simulate the vertical PSD. p_v is an input value.
N_t	Number of pixels in simulated sensor (or scene) in the transverse direction, (an input value).
N_t'	Number of points used in FFT to simulate scene in the transverse direction, (an input value).
N_X'	Number of points used in FFT to simulate scene in X-LOS direction.
$IFOV_Z$	Instantaneous-field-of-view in the vertical or Z-LOS direction in degrees, (an input value).
$IFOV_Y$	Instantaneous-field-of-view in the transverse or Y-LOS direction in degrees, (an input value).
Δ_X	Equal spacing of data points in the X-LOS direction.
B	Bore zenith angle (degrees)

This program module simulates a radiance scene using radiance, statistical and spectral estimates contained in the SHARC 4.0 radiance parameter output file, "SHARCLC.DAT". These quantities which are functions of zenith angle (Z_A) include the horizontal (L_{ch}) and vertical (L_{cv}) radiance correlation angles, the log-log slopes (indices) of the power spectral density (PSD) in the horizontal (S_h) and vertical (S_v) directions and the relative standard deviation (STD). The user would invoke this option as an alternative to the 3-D approach.

A radiance scene of (N_v) pixels in the vertical or Z-LOS direction and (N_t) pixels in the transverse or Y-LOS direction is simulated. N_v and N_t are input parameters. The simulated scene requires an input bore zenith angle (B). Actually, (N_v') points are used to simulate the scene in the Z-LOS direction, (N_t') points in the Y-LOS direction and (N_X') points in the X-LOS direction where X-LOS is in the horizontal plane and perpendicular to the Y-LOS direction. N_v' is greater than N_v, N_t' is greater than or equal to N_t, and N_X' is greater than or equal to N_v. N_t' and N_X' are input values. N_v' is described below.

A PSD filter is used to derive the radiance structure which is isotropic in horizontal planes and has a vertical PSD which is orthogonal to the horizontal PSD. The procedure amounts to a general approximation for the description of atmospheric structure. A set of N_v' horizontal rectangular regions defined as (N_t' x N_X') points are simulated stacked on top of each other. By properly scaling the spacings in the three directions , a set of N_v Y-LOS lines will occur at positions that approximate what the pixels of the sensor will view. $N_v' = N_v + N_{rv}$ where N_{rv} is a number of additional vertical

values used to overcome the relaxation time of an AR filter used to form the desired PSD in the vertical direction. N_{rv} is an input value. As N_{rv} increases, the relaxation problem diminishes. If N_{rv} is not much greater than N_v, a small fraction of the program module computer time is being used for these N_{rv} points. The value of N_{rv} can be adjusted accordingly. The default value for N_{rv} has been set to 51.

Initially, N_v' horizontal planes each of dimension $(N_t' \text{ x } N_X')$ of normally distributed random numbers are simulated. These planes are equally spaced in the instantaneous-field-of-view in the Z-LOS direction ($IFOV_Z$) and in the Y-LOS direction ($IFOV_Y$). Both $IFOV_Z$ and $IFOV_Y$ are input values. The spacing in the X-LOS direction (Δ_X) is also of equal length. $\Delta_X = IFOV_Y \text{ x COSINE}(B)$. The standard deviation simulated at this point is 1. The first N_{rv} values of the vertical lines of data are assigned the L_{cv} and S_v of the largest zenith angle (Z_A) to be simulated. The remainder of each of these lines are assigned the L_{cv} and S_v values to be simulated in descending order. The variation in the vertical direction is then filtered onto these lines running in the vertical direction. The method applies a recursive filter with (p_v) autoregressive (AR) coefficients to each of the vertical lines. The coefficients of the filter are set to approximate the L_{cv} and S_v values using a Wittwer-Kilb (W-K) model at the point which is being filtered. Generally, the more coefficients that are used the better the desired PSD will be simulated. The default value of p_v=6 was sufficient for the cases tried. Caution should be exercised in increasing p_v since the mathematics used to find the autoregressive coefficients assumes local stationarity of the PSD. This approximation is valid over short distances along a vertical ray.

The filter approximates the PSD at each zenith value, Z_A, from a weighted sum of filtered values immediately preceding Z_A and the original value at Z_A. The first N_{rv} values are used only to overcome the relaxation time of the filter. After filtering, the first N_{rv} values are discarded. This allows the program module to maintain only p_v+1 values of the line in core while the first N_{rv} values are being calculated. After discarding N_{rv} values of each filtered vertical line, $(N_t' \text{ x } N_X')$ vertical lines of N_v points remain. At this point, a 2-D FFT is taken of the $(N_t' \text{ x } N_X')$ values at Z_A. The 2-D FFT is accomplished by first applying 1-D FFTs to the N_X' lines of N_t' points. This is followed by applying 1-D FFTs to the N_t' lines of N_X' points of the result. The resultant values are then multiplied by Fourier coefficients to apply the desired PSD including the desired standard deviation (STD) at Z_A. The PSD is determined by the values L_{ch}, S_h and STD using a W-K model. This PSD is applied at the discrete frequencies generated by the FFT which leads to an approximation error. The approximation error occurs because the PSD is a continuous curve versus frequency and the FFT evaluates only at a set of discrete frequency values. As N_t' and/or N_X' increase, the spacing between frequencies used to approximate the continuous PSD become smaller, which results in a more accurate approximation. For this reason, N_t' can be greater than or equal to N_t and N_X' can be greater than or equal to N_v. The time used by this part of the program

logic increases faster than the quantity, $(N_X' \times N_t')^2$, a consideration when setting N_X' and N_t'.

At this stage, an inverse 2-D FFT is taken of each of the horizontal planes. The inverse 2-D FFT is applied in same way that the 2-D FFTs were applied. In the i^{th} plane resulting from the inverse FFT, the first N_t values of the i^{th} transverse line are the results put on the simulation. This is possible because Δ_X was set to $IFOV_Y$ x COSINE(B). Thus, by taking such lines for i=1,2,3,..., N_v, the simulated scene is formed.

3.3 Setting Up and Running the Program Package

3.3.1 Installation

Version 1.0A of the SIG code is provided on a tape cartridge which contains the UNIX manager script, "sig", the FORTRAN code of the interactive module, "sigint.f", and the FORTRAN code of each of the six processing modules; "tsdbpro.f", "thredint.f", "dynamic.f", "stretch.f", "nadir.f", and, "offnadir.f" and their subroutines.

The user must ensure that these files reside in a common directory. Also, the six processing module file names, as noted above, are hardwired requirements in the "sig" script.

3.3.1.1 Hardware Requirements

The software package was developed to run on a Silicon Graphics UNIX workstation (SGI INDY). On similar platforms, 160 Mbytes of main memory, ½ Gbyte of program module disk space and a minimum of 2 Gbytes of swap space are recommended.

3.3.1.2 Special Instructions

Prior to activating the SIG package, the user must ensure that the UNIX script, "sig", be executable. The UNIX statement,

```
chmod 700 sig
```

gives the user permission to read, write, and execute the file, "sig".

Also prior to activating the SIG package, the interactive program module, "sigint.f" requires a FORTRAN compilation resulting in the compiled version being named, "sigint.out". This file name is a hardwired requirement in the "sig" script. The FORTRAN instruction for this compilation on the Silicon Graphics workstation is as follows:

```
f77 sigint.f -o sigint.out
```

3.3.1.3 Auxiliary Software Definitions/Requirements

Several applications require that the IMSL library be linked to the compilation of the individual processing program module. These applications include the 3-D Temperature Structure Database Generation, the Quick Dynamic 2-D Limb View Approach, the Fast "Stretched Space" 2-D Limb View Approach, the Nadir Approach and the Off-Nadir/Off Vertical Approach. An on-site IMSL license must be defined for the individual computer being used for each of these applications. For example, the FORTRAN statement (refer to Figure 18 in Section 3.1.3),

```
setenv LM_LICENSE_FILE/appl/license/license.maxwell
```

sets the program environment such that "maxwell" is the name of the computer where the IMSL license resides. Similar definitions are required for individual computers.

In this example, the 'setenv' statement is followed by the FORTRAN compilation statement,

```
f77 dynamic.f -O2 -bytereclen -static -limsl -limslblas -mp -mips2 -o dynamic.out
```

which links the standard IMSL library, (contains math applications, statistical analysis and special functions) along with IMSLBLAS (provides extensive use of basic linear algebraic subprograms which assure uniformity and stability in vector/matrix operations), to the compilation of the Quick Dynamic 2-D Limb View program module, "dynamic.f".

All program modules use the IMSL library, except the "Brute Force" Integration module. These program modules use the IMSL subroutines and functions "fftci", "f2tcf", "gamma" and "bsks". Subroutines "fftci" and "f2tcf" calculate a fast Fourier transform (FFT). In particular, "fftci" initializes tables for "f2tcf". The arguments for "f2tcf" are (N, coef, seq, wfftc, cpy) where coef and seq are complex vectors containing the input array to the FFT and the output array, respectively. The length of these arrays is N. N can be any integer greater than 1. Array wfftc is a real array initialized by "fftci". Array cpy is a real work array.

These routines can be replaced by any complex exponential FFT subroutine(s) which can handle all the possible values of N (including non-powers of 2).

Function "gamma" has one argument, the value at which we evaluate the "gamma" function. Again this can be replaced by a substitute function which evaluates the "gamma" function.

Subroutine "bsks" has four arguments (XNU, X, N, BK). Bsks evaluates modified bessel functions of the third kind ($K_{XNU}(X)$). The output from "bsks" is the real array BK where BK(i) contains the modified bessel function for order (XNU+i-1) (i = 1,...,N). XNU is a floating point number such that $0 \leq XNU < 1$. X is the floating point value at which the modified bessel function is evaluated. N is an integer > 0. Again this can be replaced by a similar subroutine.

The following table indicates where the IMSL subroutines and functions are used.

3-D Temperature Structure Database Generator Module

Module	Subroutine (Function)	Calling Routine
"tsdbpro.f"	"fftci"	Subroutines CHHA1, REDS, REDS1
"tsdbpro.f"	"f2tcf"	Subroutines CHHA1, IFFTD, REDS, REDS1
"tsdbpro.f"	"gamma"	Subroutine FINDMO
"tsdbpro.f"	"bsks"	Subroutine FINDMO

Quick Dynamic 2-D Limb View Module

Module	Subroutine (Function)	Calling Routine
"dynamic.f"	"fftci"	Subroutines REDS, REDS1
"dynamic.f"	"f2tcf"	Subroutines IFFTD, REDS, REDS1
"dynamic.f"	"gamma"	Subroutine FINDMO
"dynamic.f"	"bsks"	Subroutine FINDMO

Fast "Stretched Space" 2-D Limb View Module

Module	Subroutine (Function)	Calling Routine
"stretch.f"	"fftci"	Main program, Subroutines SUB2, SUB3
"stretch.f"	"f2tcf"	Main program, Subroutines SUB2, SUB3
"stretch.f"	"gamma"	Subroutine FINDMO
"stretch.f	"dbsks"	Subroutine FINDMO
	"dbsks" is a double precision version of "bsks"	

Nadir Module

Module	Subroutine (Function)	Calling Routine
"nadir.f"	"fftci"	Subroutines BASFFT, FORFFT
"nadir.f"	"f2tcf"	Subroutine FORFFT
"nadir.f"	"f2tcb"	Subroutine BASFFT
	"f2tcb" is the inverse version of "f2tcf"	

Off-Nadir/Off-Vertical Module

Module	Subroutine (Function)	Calling Routine
"offnadir.f"	"fftci"	Subroutines REDS, REDS1
"offnadir.f"	"f2tcf"	Subroutines IFFTD, REDS, REDS1
"offnadir.f"	"gamma"	Subroutine FINDMO
"offnadir.f"	"bsks"	Subroutine FINDMO

Table 4. IMSL Subroutines and Functions and Associated Program Module Calling Routines.

All program modules use a group of FORTRAN functions and subroutines. These functions and subroutines are extensions available on Silicon Graphics machines. Similar functions and subroutines are usually provided on other computers. In particular the functions are "etime" and "rand". The subroutines are "date" and "srand".

Function "etime" is a real*4 function that provides the elapsed time in seconds. The argument for "etime" is a vector of length two of type real*4. This vector contains additional information about the actual time of the call to etime but is not used by any of the modules. If timing for the modules is not important the user can substitute the provided function "noetime" for function "etime". In this case the program module will indicate that no time elaspes during execution.

Subroutine "date" is called with one argument of type character*9. The output value is the date. If the date at which a module is run is not important, the user can substitute the provided function "nodate" for function "date". In this case the modules will write the date as, no date.

Subroutine "srand" is called with one argument of type integer*4. This argument's value is the seed of the pseudo-random number generator. Function "rand" is type real*8. It has no arguments. Function "rand" returns a number from a uniform probability distribution with limits 0 to 1. This uniform probability distribution is then converted to Gaussian distribution in subroutine "GAUSS". The user can replace these pseudo-random number routines with any similar functions or subroutines. Random

number generators of type real*4 have not been checked, but would probably yield reasonable results.

The following table indicates where the subroutines and functions, as noted above, are used.

3-D Temperature Structure Database Generator Module

Module	Subroutine (Function)	Calling Routine
"tsdbpro.f"	"etime(T)"	Main program (real*4 etime, T(2))
"tsdbpro.f"	"date(dddd)"	Main program (character*9 dddd)
"tsdbpro.f"	"srand(seed)"	Main program (integer*4 seed)
"tsdbpro.f"	"rand"	Function GAUSS (real*8 rand)

Limb View Brute Force 3-D Integration Module

Module	Subroutine (Function)	Calling Routine
"thredint.f"	"etime(T)"	Main program (real*4 etime, T(2))

Quick Dynamic 2-D Limb View Module

Module	Subroutine (Function)	Calling Routine
"dynamic.f"	"etime(T)"	Main program (real*4 etime, T(2)) Subroutines REDS, REDS1
"dynamic.f"	"date(dddd)"	Main program (character*9 dddd)
"dynamic.f"	"srand(seed)"	Main program (integer*4 seed)
"dynamic.f"	"rand"	Function GAUSS (real*8 rand)

Fast "Stretched Space" 2-D Limb View Module

Module	Subroutine (Function)	Calling Routine
"stretch.f"	"etime(T)"	Main program (real*4 etime, T(2))
"stretch.f"	"date(dddd)"	Main program (character*9 dddd)
"stretch.f"	"srand(seed)"	Main program (integer*4 seed)
"stretch.f"	"rand"	Function GAUSS (real*8 rand)

Nadir Module

Module	Subroutine (Function)	Calling Routine
"nadir.f"	"date(dddd)"	Main program (character*9 dddd)
"nadir.f"	"srand(seed)"	Main program (integer*4 seed)
"nadir.f"	"rand"	Function GAUSS (real*8 rand)

Off-Nadir/Off-Vertical Module

Module	Subroutine (Function)	Calling Routine
"offnadir.f"	"etime(T)"	Main program (real*4 etime, T(2))
"offnadr.f"	"date(dddd)"	Main program (character*9 dddd)
"offnadr.f"	"srand(seed)"	Main program (integer*4 seed)
"offnadr.f"	"rand"	Function GAUSS (real*8 rand)

Table 5. FORTRAN Subroutines and Functions (Extensions on the Silicon Graphics Machines) and Associated Program Module Calling Routines.

3.3.2 Running the Program Package

To initiate the process, the user enters the instruction, 'sig', at the computer prompt which activates the UNIX manager script, "sig". Control is passed to the FORTRAN program module, "sigint.f", which initially determines interactively the application to be run. The determination is made by means of a decision-tree menu presentation. An example session of the top level menu followed by lower level menus is shown in Figure 22. The prompts from "sig" are capitalized. User responses are contained in braces, { }. User commands consisting of module names are contained in brackets, [ ]. Text, inserted into the session for clarification, is contained in < >.

```
[sig]

PHILLIPS LABORATORY
  GEOPHYSICS DIRECTORATE/GPOS
  HANSCOM AFB, MA 01731

  SHARC IMAGE GENERATOR (SIG)
  V1.0A


  CHOOSE METHOD TO PRODUCE RADIANCE STRUCTURE IMAGES
  1 = LIMB VIEW
  2 = NADIR
  3 = OFF-NADIR
  4 = EXIT
  ENTER 1, 2, 3, OR 4

{1}

  CHOOSE SPECIFIC LIMB VIEW APPROACH
  1 = 3-D BRUTE FORCE APPROACH
  2 = QUICK DYNAMIC APPROACH
  3 = STRETCHED SPACE APPROACH
  4 = RETURN TO PREVIOUS MENU
  ENTER 1, 2, 3, OR 4
```

```
{1}

  BRUTE FORCE APPROACH
  1 = CREATE NEW 3-D TEMPERATURE STRUCTURE DATABASE
  2 = USE OLD 3-D TEMPERATURE STRUCTURE DATADASE
  3 = RETURN TO PREVIOUS MENU
  ENTER 1, 2, OR 3

{2}

  USING AN EXISTING 3-D TEMPERATURE STRUCTURE
  DATABASE TO RENDER STRUCTURE SCENES FOR
  VARIABLE PATH LIMB VIEWS

  INPUT FILE NAMES ARE HARDWIRED (THREED.INP & THREED.PRM)

  1 = CREATE NEW INPUT FILES
  2 = USE/EDIT OLD INPUT FILES
  3 = EXECUTE PROGRAM WITH OLD INPUT FILES
  4 = RETURN TO PREVIOUS MENU
  ENTER 1, 2, 3, OR 4

{1}

  BRUTE FORCE LIMB VIEW 3-D INTEGRATION
```

< At this point, control has passed to the interactive FORTRAN subroutine for the selected application.>

Figure 22. SIG interactive menus, which allow the user to select a particular application.

Based on the specific application chosen, program module control is passed to one of six interactive subroutines which determine by user interface the name(s) of the input database file(s) required by the particular follow-on processing program module. An example interactive session for a required database selection process is shown in Figure 23.

```
BRUTE FORCE LIMB VIEW 3-D INTEGRATION

  EXISTING DATABASE FILES (REQUIRED)

  1 = TEMPS.DB1
      (3-D TEMPERATURE DESCRIPTOR DATABASE)

  2 = TEMPS.DB2
      (3-D TEMPERATURE STRUCTURE DATABASE)

  3 = SHARCFA.DAT
      (SHARC 4.0 RADIANCE FLUCTUATION AMPLITUDE OUTPUT FILE)


  ENTER # OF FILE NAME TO MODIFY OR
        0 TO CONTINUE
```

```
{3}

  SPECIFY FULL PATH AND FILE NAME, I.E., /DIREC/SHARCFA.DAT

  OR, IF FILE RESIDES IN THE CURRENT DIRECTORY,

  SPECIFY JUST THE FILE NAME, I.E., SHARCFA.DAT

{SIGTST.3D}

  BRUTE FORCE LIMB VIEW 3-D INTEGRATION

  EXISTING DATABASE FILES (REQUIRED)

  1 = TEMPS.DB1
      (3-D TEMPERATURE DESCRIPTOR DATABASE)

  2 = TEMPS.DB2
      (3-D TEMPERATURE STRUCTURE DATABASE)

  3 = SIGTST.3D
      (SHARC 4.0 RADIANCE FLUCTUATION AMPLITUDE OUTPUT FILE)


  ENTER # OF FILE NAME TO MODIFY OR
        0 TO CONTINUE

{0}

  READING 3-D TEMPERATURE DESCRIPTOR DATABASE FILE

  FILE WAS READ SUCCESSFULLY

  PRESS ENTER TO CONTINUE

{ENTER}

  READING SHARC 4.0 RADIANCE FLUCTUATION AMPLITUDE OUTPUT FILE

  SHARC FILE WAS READ SUCCESSFULLY

  PRESS ENTER TO CONTINUE

{ENTER}
```

<For a detailed description of “TEMPS.DB1”, “TEMPS.DB2”, “SHARCFA.DAT”,>
<and other database files accessed by these modules, refer to Section 4.>

Figure 23. SIG selection process, which allows the user to interactively define the full path and unique name of each required input database file.

At this stage, the user begins the interactive parameter selection process with either the default input menu data or the menu data from the old .INP file. In this example interactive session (refer to Figure 22 in this Section), the user chose to create a new input menu data file, the default option. In the event that input menu data files (.INP and .PRM) do not exist (i.e., prior to the initial program module run for each

application) the user's only choice is to initialize with default input menu data. An example interactive session of a default input menu selection is shown in Figure 24.

```
BRUTE FORCE LIMB VIEW 3-D INTEGRATION

   MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: THREED.INP & THREED.PRM)

   1 =              0 TEMPERATURE (0=SHARC / 1=U.S. STANDARD ATMOSPHERE MODEL)
   2 =            256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
   3 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
   4 =            256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
   5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
   6 =              1 (1 => SINGLE SCENE  /  2 => MULTIPLE SCENES)

  ENTER # OF ITEM TO MODIFY OR
        0 TO CONTINUE
```

Figure 24. Default input menu data. This menu allows the user to interactively modify the processing program module input data.

Hardwired file names (.INP and .PRM) are associated with the final input menu data. In addition, the user has the option of creating backup input menu data files for archive purposes and possible re-use at a later time. A sample interactive session of creating input menu data backup files is shown in Figure 25.

```
BRUTE FORCE LIMB VIEW 3-D INTEGRATION    (MULTIPLE SCENES)

  PROGRAM INPUT PARAMETERS (HARDWIRED FILE NAMES: THREED.INP & THREED.PRM)

   1 =              0 TEMPERATURE (0=SHARC / 1=U.S. STANDARD ATMOSPHERE MODEL)
   2 =            256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
   3 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
   4 =            256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
   5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
   6 = 8.000000E+01 BORE TANGENT ALTITUDE (BTA) IN KM
   7 = 9.000000E+01 MAXIMUM BORE TANGENT ALTITUDE (KM) [OBTAINED FROM BTA(S)]

  BORE TANGENT ALTITUDES (MULTIPLE SCENES)

    1 =  80.00        2 =  85.00        3 =  90.00

  ENTER 2 TO MAKE FURTHER MODIFICATIONS
        1 TO GENERATE BACKUP INPUT MENU FILES (OPTIONAL)
        0 TO CONTINUE

{1}

  SPECIFY FULL PATH NAME FOR BACKUP INPUT MENU FILES (E.G. /DIR1/DIR2/)
  OR PRESS ENTER FOR CURRENT DIRECTORY.

{ENTER}

  SPECIFY .INP & .PRM BACKUP INPUT MENU FILE PREFIX
  OR PRESS ENTER FOR DEFAULT PREFIX (THREED2)
```

```
{ENTER}
```

Figure 25. Final input menu data followed by user interface option to create backup input menu data files.

The user is now presented with default program module output file names and given the option of specifying a full path name and/or a file prefix. A sample session of output file name selection is shown in Figure 26.

```
BRUTE FORCE LIMB VIEW 3-D INTEGRATION

  DEFAULT OUTPUT FILE NAMES

  THREED.ERR    (ERRORS)
  THREED.IN1    (INFORMATIONAL 1)
  THREED.IN2    (INFORMATIONAL 2)
  THREED.BS#    (BACKGROUND + STRUCTURE RADIANCE IMAGE FILE)
  THREED.BG#    (BACKGROUND RADIANCE IMAGE FILE)

  SPECIFY FULL PATH NAME FOR PROGRAM OUTPUT FILES (E.G. /DIR1/DIR2/)
  OR PRESS ENTER FOR CURRENT DIRECTORY.

{ENTER}

  SPECIFY THE OUTPUT FILE PREFIX
  OR PRESS ENTER FOR DEFAULT PREFIX (THREED)

{ENTER}
```

Figure 26. Interactive menu, which allows the user to define the full path and prefix of the output file names.

Finally, the user is presented with a menu of action items as noted in Figure 27.

```
BRUTE FORCE LIMB VIEW 3-D INTEGRATION

  INDICATE DESIRED ACTION

  1 = MAKE FURTHER MODIFICATIONS

  2 = CREATE INPUT MENU FILES, COMPILE/EXECUTE PROGRAM, & EXIT

  3 = CREATE INPUT MENU FILES AND EXIT

  4 = EXIT WITH NO CHANGES

  ENTER 1, 2, 3, OR 4

2
```

Figure 27. A menu of action items for the user to choose.

In the event that the user chooses to execute the program module application, the following warning is given.

```
WARNING: DO NOT INITIATE ANOTHER 3-D INTEGRATION APPLICATION
         UNTIL THIS 3-D INTEGRATION SUBMISSION RUNS TO
         COMPLETION.
```

In the event that the user chooses to create input menu files, the following message is given.

```
THE INPUT MENU FILES HAVE BEEN CREATED.
THREED.INP
THREED.PRM
```

In the event, that the user has requested backup input menu files, the following message is given.

```
THE BACKUP INPUT MENU FILES HAVE ALSO BEEN CREATED.
THREED2.INP
THREED2.PRM
```

At this point, the user is no longer interacting with the program package and control is passed back to the UNIX manager script, “sig”, which in turn creates and submits the UNIX batch script for the application. The processing program module is thereby compiled and executed if such a choice was made in batch mode. Since the file names must remain unique during the execution of a specific job, it is important to note that no other submission for the particular application, i.e., limb view brute force 3-D integration approach, be made until the existing submission runs to conclusion. However, distinct applications, i.e., nadir and off-nadir approaches, may be submitted concurrently. Finally, after each submission, the user should examine the various error (.ERR) and informational (.INF) files to check on the integrity of the processing. In the event of possible execution errors, the following message is given.

```
UPON JOB COMPLETION, THE USER SHOULD EXAMINE THE sig3din.err
FILE TO ENSURE THAT THE JOB HAS NOT ENCOUNTERED EXECUTION
PROBLEMS
```

For a more detailed presentation of sample input files, output files and interactive sessions associated with each application, refer to Section 4.

Test cases for each program application are presented in Appendix B. These include input menu data and 2-D images.

4 PROGRAM IMPLEMENTATION

For each of the six processing program modules, input files, output files, and interactive sessions, are presented in the following sections. In the case of binary output database files, formats and FORTRAN read statements are provided. In general, text inserted for clarification is contained in < >. In the interactive sessions, prompts from "sig" are capitalized, user responses are contained in braces, { }, and user commands consisting of modular names are contained in brackets, [ ]. The FORTRAN program files have hardwired file names, as noted below.

4.1 3-D Temperature Structure Database Module - "tsdbpro.f" (hardwired file name)

4.1.1 Module Input Files

The 3-D Temperature Structure Database module requires 2 ASCII input files; a menu data file and a parameter file. These files have hardwired file names, as noted below. They can be saved as backup files for future use, (refer to Section 4.1.3).

4.1.1.1 Menu Data File - "TEMPS.INP" (hardwired file name)

<"TEMPS.INP" file required for the 3-D Temperature Structure Database Module>

<Sample "TEMPS.INP" file>

```
TEMPS.INF
TEMPS.ERR
TEMPS.DB1
TEMPS.DB2
       12345 5 DIGIT RANDOM NUMBER SEED
6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
        1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
           6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
          51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
        1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
          64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
         125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)
```

4.1.1.2 Parameter File - "TEMPS.PRM" (hardwired file name)

<"TEMPS.PRM" file required for the 3-D Temperature Structure Database Module>

<Sample "TEMPS.PRM" file>

```
PARAMETER (NUMH1MAX=                1024)
PARAMETER (NUMH2MAX=                  64)
PARAMETER (NUMCOEFVMAX=                  6)
PARAMETER (MAXH1H2=               1024)
PARAMETER (NUMVMAX=               1101)
PARAMETER (NALIASMAX=                125)
PARAMETER (NALIAS1MAX=                 1)
```

4.1.2 Module Output Files

The 3-D Temperature Structure Database module generates 3 ASCII output files; an informational file, an error file, and a temperature descriptor database file. The module also generates 1 binary ouput file, a temperature structure database file. These files have default file names, as noted below.

4.1.2.1 Informational File - "TEMPS.INF" (default file name)

<"TEMPS.INF" file generated by the 3-D Temperature Structure Database Module>

<Sample "TEMPS.INF" file>

```
12345 =RANDOM NUMBER SEED
05-Dec-96 OUTPUT FROM TEMPERATURE STRUCTURE DATABASE GENERATION PROGRAM
 2.666666984558E+00 SLOPE OF HORIZONTAL PSD
 3.000000000000E+00 SLOPE OF VERTICAL PSD
 2.0000E-01 SPACING IN TRANSVERSE DIRECTION  AT LOWEST ALTITUDE (KM)
 1.6000E+03 LENGTH ALONG LOS.
  64 NUMBER OF POINTS ALONG LOS.
 2.0000E-01 SPACING IN VERTICAL DIRECTION (KM)
 125 NUMBER OF BRANCHES FOR ALIASING ALONG THE LOS
   1 NUMBER OF BRANCHES FOR ALIASING IN THE TRANSVERSE DIRECTION
     1024 NUMBER OF VALUES IN THE TRANSVERSE DIRECTION
     1101 NUMBER OF VALUES IN THE VERTICAL DIRECTION
        6 NUMBER OF COEFFICIENTS USED IN LINEAR PREDICTOR IN THE VERTICAL DIRECTION
       51 NUMBER OF HORIZONTAL SHEETS USED FOR INITIALIZATION
 1.6000E+03 LENGTH ALONG LOS
       64 NUMBER OF VALUES ALONG LOS
 2.5397E+01 SPACING ALONG LINE OF SIGHT (KM) AT  3.0000E+01 (KM)
TOTAL TIME OF RUN=  1.3097E+02 SECONDS
```

4.1.2.2 Error File - "TEMPS.ERR" (default file name)

<"TEMPS.ERR" file generated by the 3-D Temperature Structure Database Module>

<Sample "TEMPS.ERR" file>

```
29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
```

4.1.2.3 3-D Temperature Descriptor Database - "TEMPS.DB1" (default file name)

<"TEMPS.DB1" file generated by the 3-D Temperature Structure Database Module>

<Sample "TEMPS.DB1" file>

```
12345 =RANDOM NUMBER SEED
05-Dec-96 OUTPUT FROM TEMPERATURE STRUCTURE DATABASE GENERATION PROGRAM
 3.0000E+01 THIS IS Z1 WHICH IS THE LOWEST ALTITUDE SIMULATED
 6.3710E+03 THIS IS RE WHICH IS THE RADIUS OF THE EARTH
THE SPACING (DTZ) IN THE TRANSVERSE OR LOS DIRECTIONS AT ALTITUDE Z
IS RELATED TO THE SPACING (DTZ1) AT ALTITUDE Z1 BY THE FORMULA.
DTZ=(RE+Z)*DTZ1/(RE+Z1)


 2.6667E+00 SLOPE OF HORIZONTAL PSD (2-D)
 3.0000E+00 SLOPE OF VERTICAL PSD (1-D)
 2.0000E-01 SPACING IN TRANSVERSE DIRECTION AT LOWEST ALTITUDE
 2.0000E-01 SPACING  IN THE VERTICAL DIRECTION (KM)
1024 NUMBER OF TRANSVERSE VALUES
11[illegible] NUMBER OF VERTICAL VALUES
  64 NUMBER OF VALUES ALONG LINE OF SIGHT
  51 NUMBER OF HORIZONTAL SHEETS FOR INITIALIZATION
 2.5397E+01 SPACING ALONG LINE OF SIGHT (KM) AT  3.0000E+01 (KM)
 125 NUMBER OF BRANCHES FOR ALIASING ALONG THE LOS
   1 NUMBER OF BRANCHES FOR ALIASING IN THE TRANSVERSE DIRECTION
CREATE A FILE CONSISTING OF BYTES
EACH OF WHICH REPRESENTS A NUMBER BETWEEN -128 AND +127.
THIS IS DIVIDED INTO RECORDS AS THE FOLLOWING LOGIC INDICATES
NUM=0
DO I=1,NUMBER OF VERTICAL POINTS
DO J=1,NUMBER OF POINTS ALONG THE LINE OF SIGHT
NUM=NUM+1
WRITE (8,REC=NUM) (VALUE(I,K,J),K=1,NUMBER OF TRANSVERSE POINTS)
END DO
END DO
FOR I=    1,ALTITUDE=  3.0000E+01KM, (DT/T)= -1.7591E-03+  4.2289E-04*VALUE
FOR I=    2,ALTITUDE=  3.0200E+01KM, (DT/T)= -2.6707E-03+  4.2749E-04*VALUE
FOR I=    3,ALTITUDE=  3.0400E+01KM, (DT/T)= -7.2640E-04+  4.2341E-04*VALUE
FOR I=    4,ALTITUDE=  3.0600E+01KM, (DT/T)=  1.6520E-03+  4.2787E-04*VALUE
FOR I=    5,ALTITUDE=  3.0800E+01KM, (DT/T)=  6.4198E-03+  4.8445E-04*VALUE
FOR I=    6,ALTITUDE=  3.1000E+01KM, (DT/T)=  4.6526E-03+  4.8227E-04*VALUE
FOR I=    7,ALTITUDE=  3.1200E+01KM, (DT/T)=  5.3244E-03+  4.6670E-04*VALUE
FOR I=    8,ALTITUDE=  3.1400E+01KM, (DT/T)=  5.7936E-03+  4.6818E-04*VALUE
FOR I=    9,ALTITUDE=  3.1600E+01KM, (DT/T)= -1.6452E-03+  5.0711E-04*VALUE
FOR I=   10,ALTITUDE=  3.1800E+01KM, (DT/T)= -7.2081E-03+  5.3344E-04*VALUE
FOR I=   11,ALTITUDE=  3.2000E+01KM, (DT/T)= -4.0623E-03+  5.0041E-04*VALUE
```

```
FOR I=  12,ALTITUDE=  3.2200E+01KM,  (DT/T)= -3.4358E-03+  4.8226E-04*VALUE
FOR I=  13,ALTITUDE=  3.2400E+01KM,  (DT/T)= -3.0839E-03+  4.7150E-04*VALUE
 .
 .
 .
```

<where value is the byte value retrieved from "TEMPS.DB2">

4.1.2.4 3-D Temperature Structure Database - "TEMPS.DB2" (default file name)

The temperature structure output database generated by the 3-D Temperature Structure Database module consists of a particular realization from a statistical model of the fractional fluctuation of temperature (DT/T) versus a background model of the temperature. The binary file consists of bytes, each of which represents a number between -128 and +127. The factors to convert these byte values to DT/T and the format of the contents of this file are presented on the ASCII descriptor database file, displayed above. The file contains binary data consisting of a 3 dimensional I-J-K array of byte values where I ranges from 1 to the number of vertical (Z-LOS) points, J from 1 to the number of X-LOS points, and K from 1 to the number of transverse (Y-LOS) points. The file is direct access and the data can be read with the following FORTRAN statements.

```
NREC=0
DO I=1,NZLOS
DO J=1,NXLOS
NREC=NREC+1
READ(NTAPE,REC=NREC) (VALUE(I,K,J),K=1,NYLOS)
END DO
END DO
```

4.1.3 Sample Interactive Session

<Sample interactive session for the 3-D Temperature Structure Database Module>

[sig]

```
PHILLIPS LABORATORY
GEOPHYSICS DIRECTORATE/GPOS
HANSCOM AFB, MA 01731

SHARC IMAGE GENERATOR (SIG)
V1.0A


CHOOSE METHOD TO PRODUCE RADIANCE STRUCTURE IMAGES
1 = LIMB VIEW
2 = NADIR
3 = OFF-NADIR
4 = EXIT
ENTER 1, 2, 3, OR 4
```

{1}

```
CHOOSE SPECIFIC LIMB VIEW APPROACH
1 = 3-D BRUTE FORCE APPROACH
2 = QUICK DYNAMIC APPROACH
3 = STRETCHED SPACE APPROACH
4 = RETURN TO PREVIOUS MENU
ENTER 1, 2, 3, OR 4
```

{1}

```
BRUTE FORCE APPROACH
1 = CREATE NEW 3-D TEMPERATURE STRUCTURE DATABASE
2 = USE OLD 3-D TEMPERATURE STRUCTURE DATADASE
3 = RETURN TO PREVIOUS MENU
ENTER 1, 2, OR 3
```

{1}

```
CREATING A 3-D TEMPERATURE STRUCTURE DATABASE

INPUT FILE NAMES ARE HARDWIRED (TEMPS.INP & TEMPS.PRM)

1 = CREATE NEW INPUT FILES
2 = USE/EDIT OLD INPUT FILES
3 = EXECUTE PROGRAM WITH OLD INPUT FILES
4 = RETURN TO PREVIOUS MENU
ENTER 1, 2, 3, OR 4
```

{1}

```
 NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: TEMPS.INP & TEMPS.PRM)

 1 =        12345 5 DIGIT RANDOM NUMBER SEED
 2 = 6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
 3 = 2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
 4 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
 5 = 3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 6 = 2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
 7 =         1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
 8 =            6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
 9 =           51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
10 = 2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
11 =         1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
12 = 1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
13 =           64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
14 =          125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{6}

```
ITEM  6
VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS


       0.1 < RANGE <      1.
           =       =

CURRENT VALUE = 2.000000E-01

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE = 2.000000E-01
```

{0}

```
THE MODEL IS GOOD FOR   10 KM < ALTITUDES < 250 KM.
                                 =             =

THE HIGHEST ALTITUDE SIMULATED =      250.00 KILOMETERS
DEFINED BY ITEM5+ITEM6*(ITEM7-1), WHERE,

  30.0000 = (ITEM 5)  LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 0.200000 = (ITEM 6)  VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
     1101 = (ITEM 7)  NUMBER OF VERTICAL VALUES FOR TS SIMULATION

FOR THIS VALUE, THE NUMBER OF ITERATIONS TO START THE PROCESS
(ITEM 9) WAS RECALCULATED AS      51

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
 NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: TEMPS.INP & TEMPS.PRM)

 1 =         12345 5 DIGIT RANDOM NUMBER SEED
 2 = 6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
 3 = 2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
 4 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
 5 = 3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 6 = 2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
 7 =          1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
 8 =             6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
 9 =            51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
10 = 2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
11 =          1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
12 = 1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
13 =            64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
14 =           125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{7}

```
ITEM  7
NUMBER OF VERTICAL VALUES FOR TS SIMULATION


         2 < RANGE <    2500
           =       =

CURRENT VALUE =   1101

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =   1101
```

{0}

```
THE MODEL IS GOOD FOR   10 KM < ALTITUDES < 250 KM.
                              =           =

THE HIGHEST ALTITUDE SIMULATED =     250.00 KILOMETERS
DEFINED BY ITEM5+ITEM6*(ITEM7-1), WHERE,

  30.0000 = (ITEM 5)  LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 0.200000 = (ITEM 6)  VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
     1101 = (ITEM 7)  NUMBER OF VERTICAL VALUES FOR TS SIMULATION

THE SIZE OF THE OUTPUT DATA BASE =       72.2 MEGABYTES,
DEFINED BY THE PRODUCT OF ITEMS 13, 11 & 7, WHERE,

       64 = (ITEM 13)  NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
     1024 = (ITEM 11)  NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
     1101 = (ITEM 7)  NUMBER OF VERTICAL VALUES FOR TS SIMULATION

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
 NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: TEMPS.INP & TEMPS.PRM)

 1 =         12345 5 DIGIT RANDOM NUMBER SEED
 2 = 6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
 3 = 2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
 4 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
 5 = 3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 6 = 2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
 7 =          1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
 8 =             6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
 9 =            51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
10 = 2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
11 =          1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
12 = 1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
13 =            64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
14 =           125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{9}

```
ITEM  9
NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS

THIS NUMBER DEFINES HOW MANY HORIZONTAL SHEETS ARE SIMULATED
BEFORE A SHEET IS ACTUALLY ACCEPTED AS THE FIRST HORIZONTAL
SHEET. THIS PROCEDURE IS REQUIRED SINCE THE A.R. MODEL HAS A
RELAXATION TIME.

        10 < RANGE <    2000
           =        =

CURRENT VALUE =     51

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =     51
```

{0}

```
NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: TEMPS.INP & TEMPS.PRM)

 1 =         12345 5 DIGIT RANDOM NUMBER SEED
 2 = 6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
 3 = 2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
 4 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
 5 = 3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 6 = 2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
 7 =          1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
 8 =             6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
 9 =            51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
10 = 2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
11 =          1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
12 = 1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
13 =            64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
14 =           125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{10}

```
ITEM 10
TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM

THIS SPACING DETERMINES THE NYQUIST FREQUENCY OF THE
SIMULATION. THE LOGIC ASSUMES NO POWER ABOVE THE
NYQUIST FREQUENCY. THE LOGIC ALSO ASSUMES A CYLINDRICAL
EARTH. IF THE LENGTH PERPENDICULAR TO THE LOS IS
TOO LONG, THIS IS A POOR ASSUMPTION.

       0.1 < RANGE <      5.
           =        =

CURRENT VALUE = 2.000000E-01

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE = 2.000000E-01
```

{0}

```
FOR THIS VALUE,

THE NYQUIST FREQUENCY = 2.500000E+00 CYCLES/KM.

THE TRANSVERSE LENGTH = 2.048000E+02 KM
DEFINED BY THE PRODUCT OF ITEMS 10 AND 11, WHERE,

2.000000E-01 = (ITEM 10)  TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
        1024 = (ITEM 11)  NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: TEMPS.INP & TEMPS.PRM)

 1 =        12345 5 DIGIT RANDOM NUMBER SEED
 2 = 6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
 3 = 2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
 4 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
 5 = 3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 6 = 2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
 7 =         1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
 8 =            6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
 9 =           51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
10 = 2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
11 =         1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
12 = 1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
13 =           64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
14 =          125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{11}

```
ITEM 11
NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION

THE NUMBER IS USED IN A FAST FOURIER TRANSFORM WHICH WILL
RUN FASTER IF THE NUMBER IS EQUAL TO SOME POWER OF 2.

          2 ≤ RANGE ≤    8192

CURRENT VALUE =   1024

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =   1024
```

{0}

```
FOR THIS VALUE,

THE TRANSVERSE LENGTH = 2.048000E+02 KM
DEFINED BY THE PRODUCT OF ITEMS 10 AND 11, WHERE,

2.000000E-01 = (ITEM 10)  TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
        1024 = (ITEM 11)  NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION

THE SIZE OF THE OUTPUT DATA BASE =        72.2 MEGABYTES,
DEFINED BY THE PRODUCT OF ITEMS 13, 11 & 7, WHERE,

       64 = (ITEM 13)  NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
     1024 = (ITEM 11)  NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
     1101 = (ITEM 7)  NUMBER OF VERTICAL VALUES FOR TS SIMULATION

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
 NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: TEMPS.INP & TEMPS.PRM)

 1 =        12345 5 DIGIT RANDOM NUMBER SEED
 2 = 6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
 3 = 2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
 4 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
 5 = 3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 6 = 2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
 7 =         1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
 8 =            6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
 9 =           51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
10 = 2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
11 =         1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
12 = 1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
13 =           64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
14 =          125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{12}

```
ITEM 12
LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM


        1. < RANGE <   5000.
           =       =

CURRENT VALUE = 1.600000E+03

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE = 1.600000E+03
```

{0}

```
FOR THIS VALUE,

THE SPACING ALONG THE LOS = 2.500000E+01 KM
DEFINED AS ITEM12/ITEM13, WHERE,

  1600.00 = (ITEM 12)  LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
       64 = (ITEM 13)  NUMBER OF VALUES ALONG LOS FOR TS SIMULATION

A CHANGE IN THIS NUMBER MAY REQUIRE A MODIFICATION OF THE
NUMBER OF CYCLES FOR ALIASING ALONG THE L.O.S (ITEM 14).

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
 NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: TEMPS.INP & TEMPS.PRM)

 1 =         12345 5 DIGIT RANDOM NUMBER SEED
 2 = 6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
 3 = 2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
 4 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
 5 = 3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 6 = 2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
 7 =          1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
 8 =             6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
 9 =            51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
10 = 2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
11 =          1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
12 = 1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
13 =            64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
14 =           125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{13}

```
ITEM 13
NUMBER OF VALUES ALONG LOS FOR TS SIMULATION

IN ORDER TO HAVE A DATABASE WITH MANAGEABLE SIZE, THIS
NUMBER SHOULD BE AS SMALL AS POSSIBLE. ALSO, THE NUMBER
IS USED IN A FAST FOURIER TRANSFORM WHICH WILL RUN FASTER
IF THE NUMBER IS EQUAL TO SOME POWER OF 2.

         2 < RANGE <    2048
           =       =

CURRENT VALUE =     64

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =     64
```

{0}

```
FOR THIS VALUE,

THE SPACING ALONG THE LOS = 2.500000E+01 KM
DEFINED AS ITEM12/ITEM13, WHERE,

  1600.00 = (ITEM 12)  LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
       64 = (ITEM 13)  NUMBER OF VALUES ALONG LOS FOR TS SIMULATION

THE SIZE OF THE OUTPUT DATA BASE =       72.2 MEGABYTES,
DEFINED BY THE PRODUCT OF ITEMS 13, 11 & 7, WHERE,

       64 = (ITEM 13)  NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
     1024 = (ITEM 11)  NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
     1101 = (ITEM 7)  NUMBER OF VERTICAL VALUES FOR TS SIMULATION

A CHANGE IN THIS NUMBER MAY REQUIRE A MODIFICATION OF THE
NUMBER OF CYCLES FOR ALIASING ALONG THE L.O.S (ITEM 14).

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: TEMPS.INP & TEMPS.PRM)

 1 =         12345 5 DIGIT RANDOM NUMBER SEED
 2 = 6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
 3 = 2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
 4 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
 5 = 3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 6 = 2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
 7 =          1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
 8 =             6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
 9 =            51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
10 = 2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
11 =          1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
12 = 1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
13 =            64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
14 =           125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{14}

```
ITEM 14
NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)

SINCE THE NUMBER OF VALUES ALONG THE LOS (ITEM 13) IS
USUALLY SMALL, ALIASING OF THE TEMPERATURE PSD WILL OCCUR.
THE LOGIC CAN CORRECT FOR THE ALIASING BY ADDING UP THE
EFFECTS OF FREQUENCIES ABOVE 2.000000E-02 CYCLES/KM.
THE LOGIC CONSIDERS FREQUENCIES UP TO NCA TIMES THE
NYQUIST FREQUENCY. THE DEFAULT FOR NCA IS 1.250000E+02
WHICH MAKES THE LARGEST FREQUENCY SIMULATED ALONG THE LOS
APPROXIMATELY EQUAL TO THE LARGEST FREQUENCY SIMULATED
PERPENDICULAR TO THE LOS. THE LARGER NCA, THE LONGER THE
PROGRAM RUNS, OFTEN THE MAJOR CONTRIBUTOR TO THE RUN TIME.

         1 ≤ RANGE ≤     500

CURRENT VALUE =    125

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =    125
```

{0}

```
NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: TEMPS.INP & TEMPS.PRM)

 1 =        12345 5 DIGIT RANDOM NUMBER SEED
 2 = 6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
 3 = 2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
 4 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
 5 = 3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 6 = 2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
 7 =         1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
 8 =            6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
 9 =           51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
10 = 2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
11 =         1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
12 = 1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
13 =           64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
14 =          125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{0}

```
NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION
PROGRAM INPUT PARAMETERS (HARDWIRED FILE NAMES: TEMPS.INP & TEMPS.PRM)

 1 =         12345 5 DIGIT RANDOM NUMBER SEED
 2 = 6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
 3 = 2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
 4 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
 5 = 3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
 6 = 2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
 7 =          1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
 8 =             6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
 9 =            51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
10 = 2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
11 =          1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
12 = 1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
13 =            64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
14 =           125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)

ENTER 2 TO MAKE FURTHER MODIFICATIONS
      1 TO GENERATE BACKUP INPUT MENU FILES (OPTIONAL)
      0 TO CONTINUE
```

{1}

```
SPECIFY FULL PATH NAME FOR BACKUP INPUT MENU FILES (E.G. /DIR1/DIR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY .INP & .PRM BACKUP INPUT MENU FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (TEMPS2)
```

{ENTER}

```
BACKUP INPUT MENU FILE(S) ALREADY EXIST:
TEMPS2.INP
TEMPS2.PRM

ENTER 0 TO INPUT A DIFFERENT BACKUP FILE NAME OR
      1 IF FILE NAME IS ACCEPTABLE
```

{1}

```
NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

DEFAULT OUTPUT FILE NAMES

TEMPS.INF     (INFORMATIONAL)
TEMPS.ERR     (ERRORS)
TEMPS.DB1     (3-D TEMPERATURE DESCRIPTOR DATABASE)
TEMPS.DB2     (3-D TEMPERATURE STRUCTURE DATABASE)

SPECIFY FULL PATH NAME FOR PROGRAM OUTPUT FILES (E.G. /DIR1/DIR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY THE OUTPUT FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (TEMPS)
```

{ENTER}

```
PROGRAM OUTPUT FILE(S) ALREADY EXIST:
TEMPS.DB1
TEMPS.DB2

ENTER 0 TO INPUT A DIFFERENT FILE NAME(S) OR
      1 IF THE FILE NAME(S) ARE ACCEPTABLE
```

{1}

```
NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

INDICATE DESIRED ACTION

1 = MAKE FURTHER MODIFICATIONS

2 = CREATE INPUT MENU FILES, COMPILE/EXECUTE PROGRAM, & EXIT

3 = CREATE INPUT MENU FILES AND EXIT

4 = EXIT WITH NO CHANGES

ENTER 1, 2, 3, OR 4
```

{2}

```
WARNING: DO NOT INITIATE ANOTHER TEMPERATURE STRUCTURE
         DATABASE APPLICATION UNTIL THIS TEMPERATURE
         STRUCTURE DATABASE SUBMISSION RUNS TO COMPLETION.

THE INPUT MENU FILES HAVE BEEN CREATED.
TEMPS.INP
TEMPS.PRM

BACKUP INPUT MENU FILES HAVE ALSO BEEN CREATED.
TEMPS2.INP
TEMPS2.PRM
```

4.2 Limb View Brute Force 3-D Integration Module - "thredint.f" (hardwired file name)

4.2.1 Module Input Files

The Limb View 3-D Integration module requires 3 ASCII input files; a menu data file, a parameter file, and a temperature descriptor database file. The menu data and parameter files have hardwired file names, and the temperature descriptor database file has a default file name, as noted below. The menu data and parameter files can be saved as backup files for future use (refer to Section 4.2.3). The module also requires 2 binary input files; a temperature structure database file and a SHARC 4.0 radiance fluctuation amplitude output file. These binary files have default file names, as noted below.

4.2.1.1 Menu Data File - "THREED.INP" (hardwired file name)

<"THREED.INP" file required for the Limb View 3-D Integration Module>

<Sample "THREED.INP" file>

```
TEMPS.DB1
TEMPS.DB2
SIGTST.3D
THREED.ERR
THREED.IN1
THREED.IN2
THREED.BS1
THREED.BG1
           0 TEMPERATURE (0=SHARC DATA / 1=STANDARD ATMOSPHERIC MODEL)
         256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
         256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
8.000000E+01 BORE TANGENT ALTITUDE (BTA) IN KM
9.000000E+01 MAXIMUM BORE TANGENT ALTITUDE (KM) [OBTAINED FROM BTA(S)]
THREED.BS2
THREED.BG2
8.500000E+01 BORE TANGENT ALTITUDE (BTA) IN KM
THREED.BS3
THREED.BG3
9.000000E+01 BORE TANGENT ALTITUDE (BTA) IN KM
```

4.2.1.2 Parameter File - "THREED.PRM" (hardwired file name)

<"THREED.PRM" file required for the Limb View 3-D Integration Module>

<Sample "THREED.PRM" file>

```
      PARAMETER (NUMH1MAX=              1024)
      PARAMETER (NUM3FMAX=                35)
      PARAMETER (NUMBETAMAX=             256)
      PARAMETER (NUMALPPMAX=             256)
      PARAMETER (MAXSHFI=               416)
      PARAMETER (NUMH2MAX=                64)
      PARAMETER (MAXH1H2=              1024)
      PARAMETER (NUMVMAX=              1101)
      PARAMETER (NUMVALT=              1102)
```

4.2.1.3 3-D Temperature Descriptor Database - "TEMPS.DB1" (default file name)

<"TEMPS.DB1" file required for the Limb View 3-D Integration Module>

<Sample "TEMPS.DB1" file>

```
12345 =RANDOM NUMBER SEED
 05-Dec-96 OUTPUT FROM TEMPERATURE STRUCTURE DATABASE GENERATION PROGRAM
  3.0000E+01 THIS IS Z1 WHICH IS THE LOWEST ALTITUDE SIMULATED
  6.3710E+03 THIS IS RE WHICH IS THE RADIUS OF THE EARTH
```

```
THE SPACING (DTZ) IN THE TRANSVERSE OR LOS DIRECTIONS AT ALTITUDE Z
IS RELATED TO THE SPACING (DTZ1) AT ALTITUDE Z1 BY THE FORMULA.
DTZ=(RE+Z)*DTZ1/(RE+Z1)


 2.6667E+00 SLOPE OF HORIZONTAL PSD (2-D)
 3.0000E+00 SLOPE OF VERTICAL PSD (1-D)
 2.0000E-01 SPACING IN TRANSVERSE DIRECTION AT LOWEST ALTITUDE
 2.0000E-01 SPACING  IN THE VERTICAL DIRECTION (KM)
1024 NUMBER OF TRANSVERSE VALUES
1101 NUMBER OF VERTICAL VALUES
  64 NUMBER OF VALUES ALONG LINE OF SIGHT
  51 NUMBER OF HORIZONTAL SHEETS FOR INITIALIZATION
 2.5397E+01 SPACING ALONG LINE OF SIGHT (KM) AT  3.0000E+01 (KM)
 125 NUMBER OF BRANCHES FOR ALIASING ALONG THE LOS
   1 NUMBER OF BRANCHES FOR ALIASING IN THE TRANSVERSE DIRECTION
CREATE A FILE CONSISTING OF BYTES
EACH OF WHICH REPRESENTS A NUMBER BETWEEN -128 AND +127.
THIS IS DIVIDED INTO RECORDS AS THE FOLLOWING LOGIC INDICATES
NUM=0
DO I=1,NUMBER OF VERTICAL POINTS
DO J=1,NUMBER OF POINTS ALONG THE LINE OF SIGHT
NUM=NUM+1
WRITE (8,REC=NUM) (VALUE(I,K,J),K=1,NUMBER OF TRANSVERSE POINTS)
END DO
END DO
FOR I=   1,ALTITUDE=  3.0000E+01KM,  (DT/T)= -1.7591E-03+  4.2289E-04*VALUE
FOR I=   2,ALTITUDE=  3.0200E+01KM,  (DT/T)= -2.6707E-03+  4.2749E-04*VALUE
FOR I=   3,ALTITUDE=  3.0400E+01KM,  (DT/T)= -7.2640E-04+  4.2341E-04*VALUE
FOR I=   4,ALTITUDE=  3.0600E+01KM,  (DT/T)=  1.6520E-03+  4.2787E-04*VALUE
FOR I=   5,ALTITUDE=  3.0800E+01KM,  (DT/T)=  6.4198E-03+  4.8445E-04*VALUE
FOR I=   6,ALTITUDE=  3.1000E+01KM,  (DT/T)=  4.6526E-03+  4.8227E-04*VALUE
FOR I=   7,ALTITUDE=  3.1200E+01KM,  (DT/T)=  5.3244E-03+  4.6670E-04*VALUE
FOR I=   8,ALTITUDE=  3.1400E+01KM,  (DT/T)=  5.7936E-03+  4.6818E-04*VALUE
FOR I=   9,ALTITUDE=  3.1600E+01KM,  (DT/T)= -1.6452E-03+  5.0711E-04*VALUE
FOR I=  10,ALTITUDE=  3.1800E+01KM,  (DT/T)= -7.2081E-03+  5.3344E-04*VALUE
FOR I=  11,ALTITUDE=  3.2000E+01KM,  (DT/T)= -4.0623E-03+  5.0041E-04*VALUE
FOR I=  12,ALTITUDE=  3.2200E+01KM,  (DT/T)= -3.4358E-03+  4.8226E-04*VALUE
FOR I=  13,ALTITUDE=  3.2400E+01KM,  (DT/T)= -3.0839E-03+  4.7150E-04*VALUE
 .
 .
 .
```

<where VALUE is the byte retrieved from “TEMPS.DB2”>

4.2.1.4 3-D Temperature Structure Database - “TEMPS.DB2” (default file name)

The temperature structure database, required by the Limb View 3-D Integration module, consists of a particular realization from a statistical model of the fractional fluctuation of temperature (DT/T) versus a background model of the temperature. The binary file consists of bytes, each of which representing a number between -128 and +127. The factors to convert these byte values to DT/T and the format of the contents of this file are presented on the ASCII descriptor database file, displayed above. The file contains binary data consisting of a 3 dimensional I-J-K array of byte values where I ranges from 1 to the number of points vertical to the line-of sight (NZLOS), J from 1 to the number of points along the line of sight (NXLOS), and K from 1 to the number of points transverse to the line of sight (NYLOS). The file is direct access and the data can be read with the following FORTRAN statements.

```
NREC=0
DO I=1,NZLOS
DO J=1,NXLOS
NREC=NREC+1
READ(NTAPE,REC=NREC) (VALUE(I,K,J),K=1,NYLOS)
END DO
END DO
```

4.2.1.5 SHARC 4.0 Radiance Fluctuation Amplitude Output File - "SHARCFA.DAT" (default file name)

<"SHARCFA.DAT" file required for the Limb View 3-D Integration Module>

<For each tangent altitude, the file contains a set of segments consisting column-wise>
<of the following six parameters.>

<Column	Description	>
< 1	Apparent radiance volume emission ($W/cm^2 \cdot ster \cdot km$)	>
< 2	Apparent radiance fluctuation amplitude ($W/cm^2 \cdot ster \cdot {}^0K \cdot km$)	>
< 3	Local tangent altitude (km)	>
< 4	Local elevation angle (deg)	>
< 5	Slant range to end of segment $\cdot$ (km)	>
< 6	Temperature (${}^0K$)	>

<Sample "SHARCFA.DAT" file>

```
FILE A - Day Limb Midlat. Summer 4 micron
BANDPASS AND RESOLUTION (CM-1)             2222.200  2500.200      2.000
EARTH RADIUS (KM)                          6371.000
TEMPERATURE STANDARD DEV MULTIPLIER           1.000
HORIZONTAL CORRELATION MULTIPLIER             1.000
VERTICAL CORRELATION MULTIPLIER               1.000
TEMP SPECTRAL INDICES (HORIZ/VERT)           -1.670    -3.000
SENSOR ZENITH ANGLES (DIVERGING FOV)        105.503   111.315
SENSOR ALTITUDE (KM)                        500.000
TANGENT AND TARGET ALTITUDES                250.000   300.00
LINE-OF-SIGHT AND IMAGE PLANE RANGES       2651.80   1836.60
NUMBER OF SEGMENTS                            26
  0.75886E-15 -0.15565E-18  297.5000   -6.8351   43.1702   991.7750
  0.83889E-15 -0.19843E-18  292.5000   -6.8353   86.3405   990.7250
  0.99938E-15 -0.28455E-18  287.5000   -6.0727  135.2856   989.5250
  0.12021E-14 -0.40469E-18  282.5000   -6.0729  184.2308   988.1750
  0.14469E-14 -0.55880E-18  277.5000   -5.1950  242.2231   986.6750
  0.17593E-14 -0.77225E-18  272.5000   -5.1952  300.2154   985.0250
  0.21390E-14 -0.10449E-17  267.5000   -4.1227  375.7062   983.1000
  0.26277E-14 -0.14208E-17  262.5000   -4.1229  451.1970   980.9000
  0.30461E-14 -0.17563E-17  259.0000   -1.8886  524.0035   979.2499
  0.32848E-14 -0.19478E-17  257.0000   -1.8887  596.8100   978.1500
  0.35233E-14 -0.21392E-17  255.0000   -1.8888  669.6165   977.0500
  0.39064E-14 -0.24664E-17  253.0000   -1.8889  742.4230   975.9500
  0.42893E-14 -0.27936E-17  251.0000   -1.8890  815.2296   974.8500
```

```
  0.42893E-14 -0.27936E-17  251.0000      1.2592  888.0361    974.8500
  0.39064E-14 -0.24664E-17  253.0000      1.2593  960.8426    975.9500
  0.35233E-14 -0.21392E-17  255.0000      1.2594 1033.6490    977.0500
  0.32848E-14 -0.19478E-17  257.0000      1.2595 1106.4556    978.1500
  0.30461E-14 -0.17563E-17  259.0000      1.2596 1179.2621    979.2499
  0.26277E-14 -0.14208E-17  262.5000      3.4723 1254.7529    980.9000
  0.21390E-14 -0.10449E-17  267.5000      3.4725 1330.2437    983.1000
  0.17593E-14 -0.77225E-18  272.5000      4.6969 1388.2360    985.0250
  0.14469E-14 -0.55880E-18  277.5000      4.6971 1446.2283    986.6750
  0.12021E-14 -0.40469E-18  282.5000      5.6536 1495.1735    988.1750
  0.99938E-15 -0.28455E-18  287.5000      5.6538 1544.1187    989.5250
  0.83889E-15 -0.19843E-18  292.5000      6.4666 1587.2888    990.7250
  0.75886E-15 -0.15565E-18  297.5000      6.4667 1630.4590    991.7750
TANGENT AND TARGET ALTITUDES                  240.000    300.00
LINE-OF-SIGHT AND IMAGE PLANE RANGES        2764.95    1872.20
NUMBER OF SEGMENTS                             30
  0.75886E-15 -0.15565E-18  297.5000     -7.5239   39.0436    991.7750
  0.83889E-15 -0.19843E-18  292.5000     -7.5240   78.0873    990.7250
  0.99938E-15 -0.28455E-18  287.5000     -6.8403  121.2252    989.5250
  0.12021E-14 -0.40469E-18  282.5000     -6.8404  164.3632    988.1750
  0.14469E-14 -0.55880E-18  277.5000     -6.0773  213.2716    986.6750
  0.17593E-14 -0.77225E-18  272.5000     -6.0775  262.1801    985.0250
  0.21390E-14 -0.10449E-17  267.5000     -5.1989  320.1288    983.1000
  0.26277E-14 -0.14208E-17  262.5000     -5.1991  378.0776    980.9000
  0.32251E-14 -0.18999E-17  257.5000     -4.1258  453.5115    978.4250
  0.40021E-14 -0.25482E-17  252.5000     -4.1260  528.9454    975.6750
  0.46716E-14 -0.31205E-17  249.0000     -1.8900  601.6970    973.6000
  0.50535E-14 -0.34472E-17  247.0000     -1.8901  674.4485    972.2000
  0.54351E-14 -0.37739E-17  245.0000     -1.8902  747.2001    970.8000
  0.60582E-14 -0.43315E-17  243.0000     -1.8903  819.9517    969.4000
  0.66810E-14 -0.48891E-17  241.0000     -1.8904  892.7033    968.0000
  0.66810E-14 -0.48891E-17  241.0000      1.2602  965.4548    968.0000
  0.60582E-14 -0.43315E-17  243.0000      1.2603 1038.2063    969.4000
  0.54351E-14 -0.37739E-17  245.0000      1.2604 1110.9578    970.8000
  0.50535E-14 -0.34472E-17  247.0000      1.2605 1183.7092    972.2000
  0.46716E-14 -0.31205E-17  249.0000      1.2606 1256.4607    973.6000
  0.40021E-14 -0.25482E-17  252.5000      3.4749 1331.8947    975.6750
  0.32251E-14 -0.18999E-17  257.5000      3.4752 1407.3286    978.4250
  0.26277E-14 -0.14208E-17  262.5000      4.7004 1465.2773    980.9000
  0.21390E-14 -0.10449E-17  267.5000      4.7006 1523.2261    983.1000
  0.17593E-14 -0.77225E-18  272.5000      5.6579 1572.1345    985.0250
  0.14469E-14 -0.55880E-18  277.5000      5.6580 1621.0430    986.6750
  0.12021E-14 -0.40469E-18  282.5000      6.4714 1664.1809    988.1750
  0.99938E-15 -0.28455E-18  287.5000      6.4716 1707.3188    989.5250
  0.83889E-15 -0.19843E-18  292.5000      7.1911 1746.3625    990.7250
  0.75886E-15 -0.15565E-18  297.5000      7.1912 1785.4062    991.7750
.
.
.
```

4.2.2 Module Output Files

The Limb View 3-D Integration module generates 3 ASCII output files; 2 informational files and an error file. The module also generates 2 binary output files; a background + structure radiance database file and a background radiance database file. These files have default file names, as noted below.

4.2.2.1 Informational File 1 - "THREED.IN1" (default file name)

<"THREED.IN1" file generated by the Limb View 3-D Integration Module>

<Sample "THREED.IN1" file>

```
12345 =SEED FOR R.N.
 5.0000E+02 =ALTITUDE OF OBSERVER (KM)
29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
INTEGRATE WITH LINEAR INTERPOLATION BETWEEN VERTICAL
SHEETS USING NEAREST POINT FOR INTERPOLATION IN INTEGRATION
 3.0000E+01 LOWEST ALTITUDE SIMULATED (KM)
 6.3710E+03   =EARTH RADIUS FROM DT/T DATA BASE (KM)
 6.3710E+03   =EARTH RADIUS USED IN SHARC (KM)
 2.6667E+00 2-D SLOPE OF HORIZONTAL PSD
 3.0000E+00 1-D SLOPE OF VERTICAL PSD
 2.0000E-01 TRANSVERSE SPACING (KM) AT LOWEST ALTITUDE
 2.0000E-01 VERTICAL SPACING (KM)
 2.5397E+01 SPACING ALONG LINE OF SIGHT AT LOWEST ALTITUDE (KM)
1024 NUMBER OF VALUES TRANSVERSE TO THE LOS.
  64 NUMBER OF VALUES ALONG LOS.
1101 NUMBER OF VERTICAL VALUES
  51 NUMBER OF SHEETS FOR INITIALIZATION
NUMBER OF VERTICAL PIXELS=  256
THE SPACING BETWEEN ZENITH PIXELS IS  5.0000E-03 DEGREES
THE BORE HEIGHT ANALYZED IS  8.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  5.3283E+01 KM
LOGIC ASSUMES THE LARGEST BORE HEIGHT IN THE MULTIPLE SCENE
GENERATIONS IS LESS THAN OR EQUAL TO  9.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  6.3587E+01 KM
THE BORE HEIGHT WHICH WILL PASS THROUGH A COMMON TARGET IS  8.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  5.3283E+01 KM
CENTER ZENITH ANGLE USED=  1.1014E+02 DEGREES
NUMBER OF TRANSVERSE PIXELS=  256
SPACING BETWEEN TRANSVERSE VALUES=  5.0000E-03 DEGREES
LARGEST TRANSVERSE VALUE USED IS  6.3750E-01 DEGREES
12345 =SEED FOR R.N.
 5.0000E+02 =ALTITUDE OF OBSERVER (KM)
29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
INTEGRATE WITH LINEAR INTERPOLATION BETWEEN VERTICAL
SHEETS USING NEAREST POINT FOR INTERPOLATION IN INTEGRATION
 3.0000E+01 LOWEST ALTITUDE SIMULATED (KM)
 6.3710E+03   =EARTH RADIUS FROM DT/T DATA BASE (KM)
 6.3710E+03   =EARTH RADIUS USED IN SHARC (KM)
 2.6667E+00 2-D SLOPE OF HORIZONTAL PSD
 3.0000E+00 1-D SLOPE OF VERTICAL PSD
 2.0000E-01 TRANSVERSE SPACING (KM) AT LOWEST ALTITUDE
 2.0000E-01 VERTICAL SPACING (KM)
 2.5397E+01 SPACING ALONG LINE OF SIGHT AT LOWEST ALTITUDE (KM)
1024 NUMBER OF VALUES TRANSVERSE TO THE LOS.
  64 NUMBER OF VALUES ALONG LOS.
1101 NUMBER OF VERTICAL VALUES
  51 NUMBER OF SHEETS FOR INITIALIZATION
NUMBER OF VERTICAL PIXELS=  256
THE SPACING BETWEEN ZENITH PIXELS IS  5.0000E-03 DEGREES
THE BORE HEIGHT ANALYZED IS  8.5000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  5.8435E+01 KM
LOGIC ASSUMES THE LARGEST BORE HEIGHT IN THE MULTIPLE SCENE
GENERATIONS IS LESS THAN OR EQUAL TO  9.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  6.3587E+01 KM
THE BORE HEIGHT WHICH WILL PASS THROUGH A COMMON TARGET IS  8.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  5.3283E+01 KM
CENTER ZENITH ANGLE USED=  1.1002E+02 DEGREES
NUMBER OF TRANSVERSE PIXELS=  256
```

```
SPACING BETWEEN TRANSVERSE VALUES=  5.0000E-03 DEGREES
LARGEST TRANSVERSE VALUE USED IS  6.3750E-01 DEGREES
12345 =SEED FOR R.N.
 5.0000E+02 =ALTITUDE OF OBSERVER (KM)
29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
INTEGRATE WITH LINEAR INTERPOLATION BETWEEN VERTICAL
SHEETS USING NEAREST POINT FOR INTERPOLATION IN INTEGRATION
 3.0000E+01 LOWEST ALTITUDE SIMULATED (KM)
 6.3710E+03   =EARTH RADIUS FROM DT/T DATA BASE (KM)
 6.3710E+03   =EARTH RADIUS USED IN SHARC (KM)
 2.6667E+00 2-D SLOPE OF HORIZONTAL PSD
 3.0000E+00 1-D SLOPE OF VERTICAL PSD
 2.0000E-01 TRANSVERSE SPACING (KM) AT LOWEST ALTITUDE
 2.0000E-01 VERTICAL SPACING (KM)
 2.5397E+01 SPACING ALONG LINE OF SIGHT AT LOWEST ALTITUDE (KM)
1024 NUMBER OF VALUES TRANSVERSE TO THE LOS.
  64 NUMBER OF VALUES ALONG LOS.
1101 NUMBER OF VERTICAL VALUES
  51 NUMBER OF SHEETS FOR INITIALIZATION
NUMBER OF VERTICAL PIXELS=  256
THE SPACING BETWEEN ZENITH PIXELS IS  5.0000E-03 DEGREES
THE BORE HEIGHT ANALYZED IS  9.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  6.3587E+01 KM
LOGIC ASSUMES THE LARGEST BORE HEIGHT IN THE MULTIPLE SCENE
GENERATIONS IS LESS THAN OR EQUAL TO  9.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  6.3587E+01 KM
THE BORE HEIGHT WHICH WILL PASS THROUGH A COMMON TARGET IS  8.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  5.3283E+01 KM
CENTER ZENITH ANGLE USED=  1.0989E+02 DEGREES
NUMBER OF TRANSVERSE PIXELS=  256
SPACING BETWEEN TRANSVERSE VALUES=  5.0000E-03 DEGREES
LARGEST TRANSVERSE VALUE USED IS  6.3750E-01 DEGREES
```

4.2.2.2 Informational File 2 - “THREED.IN2” (default file name)

<”THREED.IN2” file generated by the Limb View 3-D Integration Module>

<Sample “THREED.IN2” file>

<Geometry Determination>

```
FILE A - Day Limb Midlat. Summer 4 micron
BANDPASS AND RESOLUTION (CM-1)          2222.200  2500.200     2.000
EARTH RADIUS (KM) 6371.0000
TEMPERATURE STANDARD DEV MULTIPLIER        1.000
HORIZONTAL CORRELATION MULTIPLIER          1.000
VERTICAL CORRELATION MULTIPLIER            1.000
TEMP SPECTRAL INDICES (HORIZ/VERT)        -1.670    -3.000
SENSOR ZENITH ANGLES (DIVERGING FOV)     105.503   111.315
SENSOR ALTITUDE (KM)=  500.0000
NOTE THE PROGRAM USES THE EARTH ALTITUDE USED IN SIMULATING THE DT/T DATA BASE
HOPEFULLY IT IS EXACTLY THE SAME AS THIS EARTH RADIUS OR NEARLY SO
FIRST TANGENT AND TARGET ALTITUDES (KM)  250.000  300.000
RUN FOR BORE TANGENT HEIGHT (KM)=  8.0000E+01
12345 =SEED FOR R.N.
 5.0000E+02 =ALTITUDE OF OBSERVER (KM)
29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
INTEGRATE WITH LINEAR INTERPOLATION BETWEEN VERTICAL
SHEETS USING NEAREST POINT FOR INTERPOLATION IN INTEGRATION
 3.0000E+01 LOWEST ALTITUDE SIMULATED (KM)
```

6.3710E+03 =EARTH RADIUS FROM DT/T DATA BASE (KM)
6.3710E+03 =EARTH RADIUS USED IN SHARC (KM)
2.6667E+00 2-D SLOPE OF HORIZONTAL PSD
3.0000E+00 1-D SLOPE OF VERTICAL PSD
2.0000E-01 TRANSVERSE SPACING (KM) AT LOWEST ALTITUDE
2.0000E-01 VERTICAL SPACING (KM)
2.5397E+01 SPACING ALONG LINE OF SIGHT AT LOWEST ALTITUDE (KM)
125 NUMBER OF ALIASED FREQUENCY BRANCHES USED ALONG LOS.
1 NUMBER OF ALIASED FREQUENCY BRANCHES USED ALONG TRANSVERSE.
1024 NUMBER OF TRANSVERSE VALUES
64 NUMBER OF VALUES ALONG LOS.
1101 NUMBER OF VERTICAL VALUES
51 NUMBER OF SHEETS FOR INITIALIZATION
MAXIMUM ANGLE USED ALONG LOS= 4.2630E+01 DEGREES
THIS IS AN ARC LENGTH AT THE OBSERVER ALTITUDE OF 4.7625E+03 (KM)
LARGEST ZENITH ANGLE (CALCULATED ALONG LOS) 1.1131E+02 DEGREES
TO CHECK THAT ALTITUDE IS MAXIMUM ALTITUDE, CALCULATED ALTITUDE= 2.5000E+02
NUMBER OF VERTICAL PIXELS= 256
THE SPACING BETWEEN ZENITH PIXELS IS 5.0000E-03 DEGREES
THE BORE HEIGHT ANALYZED IS 8.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF 5.3283E+01 KM
LOGIC ASSUMES THE LARGEST BORE HEIGHT IN THE MULTIPLE SCENE
GENERATIONS IS LESS THAN OR EQUAL TO 9.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF 6.3587E+01 KM
THE BORE HEIGHT WHICH WILL PASS THROUGH A COMMON TARGET IS 8.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF 5.3283E+01 KM
THE ALTITUDE FOR THE COMMON TARGET POINT IS 9.000000E+01
CENTER ZENITH ANGLE USED= 1.1014E+02 DEGREES
THIS MEANS ZENITH ANGLE VARIES BETWEEN 1.0950E+02 AND 1.107743E+02
NUMBER OF TRANSVERSE PIXELS= 256
SPACING BETWEEN TRANSVERSE VALUES= 5.0000E-03 DEGREES
LARGEST TRANSVERSE VALUE USED IS 6.3750E-01 DEGREES
HIT SIMULATED ATMOSPHERE AFTER GOING 8.6701E+02 KM
LEAVE ATMOSPHERE AFTER GOING 3.4569E+03 KM
INITIALIZATION TOOK 1.5157E+01 SECONDS
TOTAL TIME FOR CALCULATIONS= 7.9695E+02
NUMBER OF POINTS USED IN ALL INTEGRALS= 114288577
TEMPERATURE DATA BASE IS MIRRORED ALONG LOS 1.734375E+00 TIMES
TRANSVERSE WIDTH AT BOTTOM RAY 406 POINTS OF TEMPERATURE DATA BASE
TRANSVERSE WIDTH AT TOP RAY 396 POINTS OF TEMPERATURE DATA BASE
LINES BETWEEN VERTICAL SHEETS ARE DIVIDED INTO A MAXIMUM' OF 35 SUB-INTERVALS

POSITION	ALTITUDE	SLANT RANGE	TOTAL TRANSVERSE DISTANCE	ALTITUDE RANGE
BOTTOM LEFT	9.4237E+01	1.7106E+03	1.9033E+01	JUST BEFORE FIRST REFLECTION OF DT/T
TOP LEFT	1.3245E+02	1.7067E+03	1.8988E+01	JUST BEFORE FIRST REFLECTION OF DT/T
BOTTOM TANGENT	5.3283E+01	2.4371E+03		
TOP TANGENT	1.0592E+02	2.2935E+03		
CENTRAL RAY	8.0001E+01	2.3654E+03	5.2637E+01	5.3681E+01-1.0632E+02

RUN FOR BORE TANGENT HEIGHT (KM)= 8.5000E+01
12345 =SEED FOR R.N.
5.0000E+02 =ALTITUDE OF OBSERVER (KM)
29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
INTEGRATE WITH LINEAR INTERPOLATION BETWEEN VERTICAL
SHEETS USING NEAREST POINT FOR INTERPOLATION IN INTEGRATION
3.0000E+01 LOWEST ALTITUDE SIMULATED (KM)
6.3710E+03 =EARTH RADIUS FROM DT/T DATA BASE (KM)
6.3710E+03 =EARTH RADIUS USED IN SHARC (KM)
2.6667E+00 2-D SLOPE OF HORIZONTAL PSD
3.0000E+00 1-D SLOPE OF VERTICAL PSD
2.0000E-01 TRANSVERSE SPACING (KM) AT LOWEST ALTITUDE
2.0000E-01 VERTICAL SPACING (KM)
2.5397E+01 SPACING ALONG LINE OF SIGHT AT LOWEST ALTITUDE (KM)
125 NUMBER OF ALIASED FREQUENCY BRANCHES USED ALONG LOS.
1 NUMBER OF ALIASED FREQUENCY BRANCHES USED ALONG TRANSVERSE.

```
 1024 NUMBER OF TRANSVERSE VALUES
   64 NUMBER OF VALUES ALONG LOS.
 1101 NUMBER OF VERTICAL VALUES
   51 NUMBER OF SHEETS FOR INITIALIZATION
 MAXIMUM ANGLE USED ALONG LOS=  4.2630E+01 DEGREES
 THIS IS AN ARC LENGTH AT THE OBSERVER ALTITUDE OF  4.7625E+03 (KM)
 LARGEST ZENITH ANGLE (CALCULATED ALONG LOS)  1.1131E+02 DEGREES
 TO CHECK THAT ALTITUDE IS MAXIMUM ALTITUDE, CALCULATED ALTITUDE=  2.5000E+02
 NUMBER OF VERTICAL PIXELS=  256
 THE SPACING BETWEEN ZENITH PIXELS IS  5.0000E-03 DEGREES
 THE BORE HEIGHT ANALYZED IS  8.5000E+01 KM
 THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  5.8435E+01 KM
 LOGIC ASSUMES THE LARGEST BORE HEIGHT IN THE MULTIPLE SCENE
 GENERATIONS IS LESS THAN OR EQUAL TO  9.0000E+01 KM
 THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  6.3587E+01 KM
 THE BORE HEIGHT WHICH WILL PASS THROUGH A COMMON TARGET IS  8.0000E+01 KM
 THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  5.3283E+01 KM
 THE ALTITUDE FOR THE COMMON TARGET POINT IS  9.000000E+01
 CENTER ZENITH ANGLE USED=  1.1002E+02 DEGREES
 THIS MEANS ZENITH ANGLE VARIES BETWEEN  1.0938E+02 AND  1.106528E+02
 NUMBER OF TRANSVERSE PIXELS=  256
 SPACING BETWEEN TRANSVERSE VALUES=  5.0000E-03 DEGREES
 LARGEST TRANSVERSE VALUE USED IS  6.3750E-01 DEGREES
 HIT SIMULATED ATMOSPHERE AFTER GOING  8.7645E+02 KM
 LEAVE ATMOSPHERE AFTER GOING  3.4248E+03 KM
 INITIALIZATION TOOK  1.7149E+01 SECONDS
 TOTAL TIME FOR CALCULATIONS=  7.7547E+02
 NUMBER OF POINTS USED IN ALL INTEGRALS=           110446924
 TEMPERATURE DATA BASE IS MIRRORED ALONG LOS  1.703125E+00 TIMES
 TRANSVERSE WIDTH AT BOTTOM RAY      400 POINTS OF TEMPERATURE DATA BASE
 TRANSVERSE WIDTH AT TOP RAY      392 POINTS OF TEMPERATURE DATA BASE
 LINES BETWEEN VERTICAL SHEETS ARE DIVIDED INTO A MAXIMUM' OF    33 SUB-INTERVALS
     POSITION         ALTITUDE          SLANT RANGE     TOTAL TRANSVERSE DISTANCE
ALTITUDE RANGE
 BOTTOM LEFT       9.7886E+01           1.7102E+03       1.9028E+01   JUST BEFORE FIRST
REFLECTION OF DT/T
 TOP LEFT          1.3609E+02           1.7064E+03       1.8985E+01   JUST BEFORE FIRST
REFLECTION OF DT/T
 BOTTOM TANGENT    5.8435E+01           2.4234E+03
 TOP TANGENT       1.1077E+02           2.2798E+03
 CENTRAL RAY       8.5000E+01           2.3517E+03       5.2332E+01               5.8833E+01-
1.1117E+02
 RUN FOR BORE TANGENT HEIGHT (KM)=  9.0000E+01
 12345 =SEED FOR R.N.
  5.0000E+02 =ALTITUDE OF OBSERVER (KM)
 29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
 INTEGRATE WITH LINEAR INTERPOLATION BETWEEN VERTICAL
 SHEETS USING NEAREST POINT FOR INTERPOLATION IN INTEGRATION
  3.0000E+01 LOWEST ALTITUDE SIMULATED (KM)
  6.3710E+03   =EARTH RADIUS FROM DT/T DATA BASE (KM)
  6.3710E+03   =EARTH RADIUS USED IN SHARC (KM)
  2.6667E+00 2-D SLOPE OF HORIZONTAL PSD
  3.0000E+00 1-D SLOPE OF VERTICAL PSD
  2.0000E-01 TRANSVERSE SPACING (KM) AT LOWEST ALTITUDE
  2.0000E-01 VERTICAL SPACING (KM)
  2.5397E+01 SPACING ALONG LINE OF SIGHT AT LOWEST ALTITUDE (KM)
  125 NUMBER OF ALIASED FREQUENCY BRANCHES USED ALONG LOS.
    1 NUMBER OF ALIASED FREQUENCY BRANCHES USED ALONG TRANSVERSE.
 1024 NUMBER OF TRANSVERSE VALUES
   64 NUMBER OF VALUES ALONG LOS.
 1101 NUMBER OF VERTICAL VALUES
   51 NUMBER OF SHEETS FOR INITIALIZATION
 MAXIMUM ANGLE USED ALONG LOS=  4.2630E+01 DEGREES
 THIS IS AN ARC LENGTH AT THE OBSERVER ALTITUDE OF  4.7625E+03 (KM)
 LARGEST ZENITH ANGLE (CALCULATED ALONG LOS)  1.1131E+02 DEGREES
 TO CHECK THAT ALTITUDE IS MAXIMUM ALTITUDE, CALCULATED ALTITUDE=  2.5000E+02
 NUMBER OF VERTICAL PIXELS=  256
```

```
THE SPACING BETWEEN ZENITH PIXELS IS  5.0000E-03 DEGREES
THE BORE HEIGHT ANALYZED IS  9.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  6.3587E+01 KM
LOGIC ASSUMES THE LARGEST BORE HEIGHT IN THE MULTIPLE SCENE
GENERATIONS IS LESS THAN OR EQUAL TO  9.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  6.3587E+01 KM
THE BORE HEIGHT WHICH WILL PASS THROUGH A COMMON TARGET IS  8.0000E+01 KM
THIS CORRESPONDS TO A LOWEST TANGENT HEIGHT OF  5.3283E+01 KM
THE ALTITUDE FOR THE COMMON TARGET POINT IS  9.000000E+01
CENTER ZENITH ANGLE USED=  1.0989E+02 DEGREES
THIS MEANS ZENITH ANGLE VARIES BETWEEN  1.0926E+02 AND  1.105306E+02
NUMBER OF TRANSVERSE PIXELS=  256
SPACING BETWEEN TRANSVERSE VALUES=  5.0000E-03 DEGREES
LARGEST TRANSVERSE VALUE USED IS  6.3750E-01 DEGREES
HIT SIMULATED ATMOSPHERE AFTER GOING  8.8621E+02 KM
LEAVE ATMOSPHERE AFTER GOING  3.3921E+03 KM
INITIALIZATION TOOK  2.0983E+01 SECONDS
TOTAL TIME FOR CALCULATIONS=  7.5917E+02
NUMBER OF POINTS USED IN ALL INTEGRALS=          107582944
TEMPERATURE DATA BASE IS MIRRORED ALONG LOS  1.687500E+00 TIMES
TRANSVERSE WIDTH AT BOTTOM RAY     398 POINTS OF TEMPERATURE DATA BASE
TRANSVERSE WIDTH AT TOP RAY     388 POINTS OF TEMPERATURE DATA BASE
LINES BETWEEN VERTICAL SHEETS ARE DIVIDED INTO A MAXIMUM' OF    33 SUB-INTERVALS
    POSITION         ALTITUDE           SLANT RANGE     TOTAL TRANSVERSE DISTANCE
ALTITUDE RANGE
 BOTTOM LEFT       1.0155E+02           1.7098E+03        1.9024E+01   JUST BEFORE FIRST
REFLECTION OF DT/T
 TOP LEFT          1.3974E+02           1.7061E+03        1.8981E+01   JUST BEFORE FIRST
REFLECTION OF DT/T
 BOTTOM TANGENT    6.3587E+01           2.4097E+03
 TOP TANGENT       1.1561E+02           2.2659E+03
 CENTRAL RAY       9.0000E+01           2.3380E+03        5.2026E+01                6.3986E+01-
1.1601E+02
```

4.2.2.3 Error File - THREED.ERR (default file name)

<"THREED.ERR" file generated by the Limb View 3-D Integration Module>

<Sample "THREED.ERR" file>

```
29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
29-Nov-96 OUTPUT FROM LIMB VIEW 3-D INTEGRATION PROGRAM
```

4.2.2.4 Background + Structure Radiance Image File - "THREED.BS" (default file name)

This output file generated by the Limb View 3-D Integration module contains a synthetic array of deterministic background + stochastic structure radiance image data. The image file was written by FORTRAN unformatted write statements. The arrays were generated for an NYLOS x NZLOS pixel sensor, where NYLOS is the number of pixels in the transverse (Y-LOS) direction and NZLOS is the number of

pixels in the vertical (Z-LOS) direction. Each record of binary data consists of a 2 dimensional I-J array of 32-bit words where I ranges from 1 to NYLOS and J ranges from 1 to NZLOS. The file is direct access and the data can be read with the following FORTRAN statement.

```
READ(NTAPE) ((DATA(I,J),I=1,NYLOS),J=1,NZLOS)
```

The first point in this array, DATA(1,1), represents the bottom left corner of the image. The last point in this array, DATA(NYLOS,NZLOS), represents the top right corner of the image. (row 1, column NZ) is the bottom right of the image and (row NY, column 1) is the top left of the image.

4.2.2.5 Background Radiance Image File - "THREED.BG" (default file name)

This output file generated by the Limb View 3-D Integration module contains a synthetic array of deterministic background radiance image data. The image file was written by FORTRAN unformatted write statements. The arrays were generated for an NYLOS x NZLOS pixel sensor, where NYLOS is the number of pixels in the transverse (Y-LOS) direction and NZLOS is the number of pixels in the vertical (Z-LOS) direction. Each record of binary data consists of a 2 dimensional I-J array of 32-bit words where I ranges from 1 to NYLOS and J ranges from 1 to NZLOS. The file is direct access and the data can be read with the following FORTRAN statement.

```
READ(NTAPE) ((DATA(I,J),I=1,NYLOS),J=1,NZLOS)
```

The first point in this array, DATA(1,1), represents the bottom left corner of the image. The last point in this array, DATA(NYLOS,NZLOS), represents the top right corner of the image. (row 1, column NZ) is the bottom right of the image and (row NY, column 1) is the top left of the image.

4.2.3 Sample Interactive Session

<Sample interactive session for the Limb View 3-D Integration Module>

[sig]

```
PHILLIPS LABORATORY
GEOPHYSICS DIRECTORATE/GPOS
HANSCOM AFB, MA 01731

SHARC IMAGE GENERATOR (SIG)
V1.0A


CHOOSE METHOD TO PRODUCE RADIANCE STRUCTURE IMAGES
1 = LIMB VIEW
2 = NADIR
3 = OFF-NADIR
4 = EXIT
ENTER 1, 2, 3, OR 4
```

{1}

```
CHOOSE SPECIFIC LIMB VIEW APPROACH
1 = 3-D BRUTE FORCE APPROACH
2 = QUICK DYNAMIC APPROACH
3 = STRETCHED SPACE APPROACH
4 = RETURN TO PREVIOUS MENU
ENTER 1, 2, 3, OR 4
```

{1}

```
BRUTE FORCE APPROACH
1 = CREATE NEW 3-D TEMPERATURE STRUCTURE DATABASE
2 = USE OLD 3-D TEMPERATURE STRUCTURE DATADASE
3 = RETURN TO PREVIOUS MENU
ENTER 1, 2, OR 3
```

{2}

```
USING AN EXISTING 3-D TEMPERATURE STRUCTURE
DATABASE TO RENDER STRUCTURE SCENES FOR
VARIABLE PATH LIMB VIEWS

INPUT FILE NAMES ARE HARDWIRED (THREED.INP & THREED.PRM)

1 = CREATE NEW INPUT FILES
2 = USE/EDIT OLD INPUT FILES
3 = EXECUTE PROGRAM WITH OLD INPUT FILES
4 = RETURN TO PREVIOUS MENU
ENTER 1, 2, 3, OR 4
```

{1}

```
BRUTE FORCE LIMB VIEW 3-D INTEGRATION

EXISTING DATABASE FILES (REQUIRED)

1 = TEMPS.DB1
    (3-D TEMPERATURE DESCRIPTOR DATABASE)

2 = TEMPS.DB2
    (3-D TEMPERATURE STRUCTURE DATABASE)

3 = SHARCFA.DAT
    (SHARC 4.0 RADIANCE FLUCTUATION AMPLITUDE OUTPUT FILE)


ENTER # OF FILE NAME TO MODIFY OR
      0 TO CONTINUE
```

{3}

```
SPECIFY FULL PATH AND FILE NAME, I.E., /DIREC/SHARCFA.DAT

OR, IF FILE RESIDES IN THE CURRENT DIRECTORY,

SPECIFY JUST THE FILE NAME, I.E., SHARCFA.DAT
```

{SIGTST.3D}

```
BRUTE FORCE LIMB VIEW 3-D INTEGRATION

EXISTING DATABASE FILES (REQUIRED)

1 = TEMPS.DB1
    (3-D TEMPERATURE DESCRIPTOR DATABASE)

2 = TEMPS.DB2
    (3-D TEMPERATURE STRUCTURE DATABASE)

3 = SIGTST.3D
    (SHARC 4.0 RADIANCE FLUCTUATION AMPLITUDE OUTPUT FILE)


ENTER # OF FILE NAME TO MODIFY OR
      0 TO CONTINUE
```

{0}

```
READING 3-D TEMPERATURE DESCRIPTOR DATABASE FILE

FILE WAS READ SUCCESSFULLY

PRESS ENTER TO CONTINUE
```

{ENTER}

```
READING SHARC 4.0 RADIANCE FLUCTUATION AMPLITUDE OUTPUT FILE

SHARC FILE WAS READ SUCCESSFULLY

PRESS ENTER TO CONTINUE
```

{ENTER}

```
 BRUTE FORCE LIMB VIEW 3-D INTEGRATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: THREED.INP & THREED.PRM)

 1 =             0 TEMPERATURE (0=SHARC / 1=U.S. STANDARD ATMOSPHERE MODEL)
 2 =           256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 3 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 4 =           256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 6 =             1 (1 => SINGLE SCENE   /   2 => MULTIPLE SCENES)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{4}

```
ITEM  4
NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE

         2 < RANGE <    8192
           =        =

CURRENT VALUE =    256

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =    256
```

{0}

```
THE SIZE OF THE OUTPUT DATA BASE =    262144. BYTES,
DEFINED BY ITEM2*ITEM4*4, WHERE,

      256 = (ITEM 2)  NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
      256 = (ITEM 4)  NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
 BRUTE FORCE LIMB VIEW 3-D INTEGRATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: THREED.INP & THREED.PRM)

 1 =            0 TEMPERATURE (0=SHARC / 1=U.S. STANDARD ATMOSPHERE MODEL)
 2 =          256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 3 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 4 =          256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 6 =            1 (1 => SINGLE SCENE  /  2 => MULTIPLE SCENES)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{6}

```
FOR THIS RUN

ENTER 1 FOR SINGLE SCENE (ONE BORE TANGENT ALTITUDE)

ENTER 2 FOR MULTIPLE SCENES (SEVERAL BORE TANGENT ALTITUDES
            WHICH HAVE A COMMON TARGET POINT ALONG THEIR
            RESPECTIVE CENTER LINES.)
```

{2}

```
THIS CASE (MULTIPLE SCENES), REQUIRES A BORE TANGENT
ALTITUDE FOR EACH SCENE (A MINIMUM OF 2 SCENES AND A
MAXIMUM OF 9 SCENES ARE ALLOWED).

STARTING WITH A MINIMUM, THE BORE TANGENT ALTITUDES
MUST INCREASE MONOTONICALLY.


BORE TANGENT ALTITUDE (BTA) IN KM

            30. < RANGE <    250.
                =        =

ENTER BORE TANGENT ALTITUDE FOR SCENE  1
```

{80}

```
ENTER BORE TANGENT ALTITUDE FOR SCENE  2
```

{85}

```
ENTER BORE TANGENT ALTITUDE FOR SCENE  3, OR
      0 IF NO ADDITIONAL SCENES ARE REQUIRED
```

{90}

```
ENTER BORE TANGENT ALTITUDE FOR SCENE  4, OR
      0 IF NO ADDITIONAL SCENES ARE REQUIRED
```

{0}

```
  BRUTE FORCE LIMB VIEW 3-D INTEGRATION

 MULTIPLE SCENES (BORE TANGENT ALTITUDES)

SCENE  1   80.00 KM
SCENE  2   85.00 KM
SCENE  3   90.00 KM

 PRESS ENTER TO CONTINUE
```

{ENTER}

```
  BRUTE FORCE LIMB VIEW 3-D INTEGRATION

  MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: THREED.INP & THREED.PRM)

  1 =             0 TEMPERATURE (0=SHARC / 1=U.S. STANDARD ATMOSPHERE MODEL)
  2 =           256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
  3 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
  4 =           256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
  5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
  6 =             2 (1 => SINGLE SCENE  /  2 => MULTIPLE SCENES)

 ENTER # OF ITEM TO MODIFY OR
       0 TO CONTINUE
```

{0}

```
  BRUTE FORCE LIMB VIEW 3-D INTEGRATION    (MULTIPLE SCENES)

 PROGRAM INPUT PARAMETERS (HARDWIRED FILE NAMES: THREED.INP & THREED.PRM)

  1 =             0 TEMPERATURE (0=SHARC / 1=U.S. STANDARD ATMOSPHERE MODEL)
  2 =           256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
  3 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
  4 =           256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
  5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
  6 = 8.000000E+01 BORE TANGENT ALTITUDE (BTA) IN KM
  7 = 9.000000E+01 MAXIMUM BORE TANGENT ALTITUDE (KM) [OBTAINED FROM BTA(S)]

 BORE TANGENT ALTITUDES (MULTIPLE SCENES)

   1 =  80.00       2 =  85.00       3 =  90.00

 ENTER 2 TO MAKE FURTHER MODIFICATIONS
       1 TO GENERATE BACKUP INPUT MENU FILES (OPTIONAL)
       0 TO CONTINUE
```

{1}

```
SPECIFY FULL PATH NAME FOR BACKUP INPUT MENU FILES (E.G. /DIR1/DIR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY .INP & .PRM BACKUP INPUT MENU FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (THREED2)
```

{ENTER}

```
BACKUP INPUT MENU FILE(S) ALREADY EXIST:
THREED2.INP
THREED2.PRM

ENTER 0 TO INPUT A DIFFERENT BACKUP FILE NAME OR
      1 IF FILE NAME IS ACCEPTABLE
```

{1}

```
BRUTE FORCE LIMB VIEW 3-D INTEGRATION

DEFAULT OUTPUT FILE NAMES

THREED.ERR    (ERRORS)
THREED.IN1    (INFORMATIONAL 1)
THREED.IN2    (INFORMATIONAL 2)
THREED.BS#    (BACKGROUND + STRUCTURE RADIANCE IMAGE FILE)
THREED.BG#    (BACKGROUND RADIANCE IMAGE FILE)

SPECIFY FULL PATH NAME FOR PROGRAM OUTPUT FILES (E.G. /DIR1/DIR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY THE OUTPUT FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (THREED)
```

{ENTER}

```
BRUTE FORCE LIMB VIEW 3-D INTEGRATION

INDICATE DESIRED ACTION

1 = MAKE FURTHER MODIFICATIONS

2 = CREATE INPUT MENU FILES, COMPILE/EXECUTE PROGRAM, & EXIT

3 = CREATE INPUT MENU FILES AND EXIT

4 = EXIT WITH NO CHANGES

ENTER 1, 2, 3, OR 4
```

{2}

```
WARNING: DO NOT INITIATE ANOTHER 3-D INTEGRATION APPLICATION
         UNTIL THIS 3-D INTEGRATION SUBMISSION RUNS TO
         COMPLETION.

THE INPUT MENU FILES HAVE BEEN CREATED.
THREED.INP
THREED.PRM

THE BACKUP INPUT MENU FILES HAVE ALSO BEEN CREATED.
THREED2.INP
THREED2.PRM
```

4.3 Quick Dynamic 2-D Limb View Module - "dynamic.f" (hardwired file name)

4.3.1 Module Input Files

The Quick Dynamic 2-D Limb View module requires 2 ASCII input files; a menu data file and a parameter file. They can be saved as backup files for future use (refer to Section 4.3.3). The module also requires 1 binary input file, a SHARC 4.0 radiance parameter output file. The menu data and parameter files have hardwired file names, and the SHARC 4.0 radiance parameter output file has a default file name, as noted below.

4.3.1.1 Menu Data File - "DYNAMIC.INP" - (hardwired file name)

<"DYNAMIC.INP" file required for the Quick Dynamic 2-D Limb View Module>

<Sample "DYNAMIC.INP" file>

```
SIGTST.2D
DYNAMIC.IN1
DYNAMIC.IN2
DYNAMIC.ERR
DYNAMIC.BS
DYNAMIC.BG
       12345 5 DIGIT RANDOM SEED NUMBER
         256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
        1024 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
         256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
8.000000E+01 BORE TANGENT ALTITUDE (KM)
           6 NUMBER OF VERTICAL AR COEFFICIENTS
          51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
```

4.3.1.2 Parameter File - “DYNAMIC.PRM” (hardwired file name)

<”DYNAMIC.PRM” file required for the Quick Dynamic 2-D Limb View Module>

<Sample “DYNAMIC.PRM” file>

```
PARAMETER (NUMVMAX=                256)
PARAMETER (NUMH1MAX=               1024)
PARAMETER (NUMHMAX=               1024)
PARAMETER (NARMAX=                   6)
PARAMETER (MAXONEV=                 20)
PARAMETER (NUMRDMAX=                 35)
PARAMETER (NALIAS1MAX=                  1)
```

4.3.1.3 SHARC 4.0 Radiance Parameter Output File - “SHARCLC.DAT” (default file name)

<”SHARCLC.DAT” file required for the Quick Dynamic 2-D Limb View Module>

<Sample “SHARCLC.DAT” file>

```
FILE B - Day Limb Midlat. Summer 4 micron
BANDPASS AND RESOLUTION (CM-1)                    2222.200  2500.200      2.000
EARTH RADIUS (KM)                                 6371.000
TEMPERATURE STANDARD DEV MULTIPLIER                  1.000
HORIZONTAL CORRELATION MULTIPLIER                    1.000
VERTICAL CORRELATION MULTIPLIER                      1.000
TEMP SPECTRAL INDICES (HORIZ/VERT)                  -1.670    -3.000
SENSOR ZENITH ANGLES (DIVERGING FOV)               105.503   111.315
SENSOR ALTITUDE (KM)                               500.000
TANGENT  ZENITH TARGET RANGE    IMAGE PL MEAN            SIGMA/MEAN CORR ANGLE (RADIAN)    SPECTRAL INDEX
HT       ANGLE  HT              RANGE    RAD (W/SR)                 (HORIZ)    (VERT)      (HORIZ) (VERT)
  250.00 105.50 300.00 2651.80 1836.60  4.07328E-12 3.9616E-02 9.563E-02  6.400E-03  -2.501  -3.210
  240.00 105.81 300.00 2764.95 1872.20  6.33058E-12 4.3953E-02 9.246E-02  6.080E-03  -2.496  -3.215
  230.00 106.12 300.00 2871.08 1907.20  9.94061E-12 4.7073E-02 8.942E-02  5.759E-03  -2.491  -3.221
  220.00 106.41 300.00 2971.51 1941.50  1.58227E-11 4.9526E-02 8.655E-02  5.424E-03  -2.490  -3.231
  210.00 106.71 300.00 3067.21 1975.10  2.56381E-11 5.1402E-02 8.352E-02  5.079E-03  -2.486  -3.246
  200.00 106.99 300.00 3158.87 2008.10  4.24055E-11 5.2627E-02 8.027E-02  4.727E-03  -2.481  -3.255
  190.00 107.28 300.00 3247.02 2040.60  7.19352E-11 5.3223E-02 7.676E-02  4.362E-03  -2.475  -3.262
  180.00 107.56 300.00 3332.07 2072.40  1.26024E-10 5.3199E-02 7.279E-02  3.970E-03  -2.467  -3.271
  170.00 107.83 300.00 3414.35 2103.80  2.30451E-10 5.2578E-02 6.843E-02  3.553E-03  -2.456  -3.284
  160.00 108.10 300.00 3494.15 2134.60  4.48156E-10 5.1356E-02 6.391E-02  3.115E-03  -2.465  -3.314
  150.00 108.37 300.00 3571.69 2165.00  8.76742E-10 4.7279E-02 5.929E-02  2.694E-03  -2.445  -3.319
  145.00 108.50 300.00 3609.68 2180.00  1.39434E-09 4.7641E-02 5.749E-02  2.274E-03  -2.500  -3.195
  140.00 108.63 300.00 3647.17 2194.90  2.15135E-09 4.6115E-02 5.461E-02  2.066E-03  -2.500  -3.233
  135.00 108.76 300.00 3684.18 2209.70  3.53631E-09 4.4695E-02 5.122E-02  1.808E-03  -2.498  -3.217
  130.00 108.89 300.00 3720.74 2224.30  6.04537E-09 4.2836E-02 4.766E-02  1.592E-03  -2.487  -3.254
  125.00 109.02 300.00 3756.86 2238.90  1.14341E-08 4.1242E-02 4.387E-02  1.327E-03  -2.509  -3.243
  120.00 109.14 300.00 3792.55 2253.30  2.37069E-08 3.9609E-02 3.941E-02  1.108E-03  -2.489  -3.298
  115.00 109.27 300.00 3827.84 2267.70  4.74483E-08 3.0106E-02 3.709E-02  9.495E-04  -2.488  -3.256
  110.00 109.40 300.00 3862.73 2281.90  7.84997E-08 1.8822E-02 3.336E-02  9.542E-04  -2.378  -3.363
  105.00 109.52 300.00 3897.24 2296.10  1.21145E-07 1.9395E-02 3.043E-02  6.708E-04  -2.436  -3.151
  100.00 109.65 300.00 3931.39 2310.20  1.97023E-07 1.9703E-02 2.835E-02  5.855E-04  -2.418  -3.332
   95.00 109.77 300.00 3965.17 2324.10  3.63771E-07 1.6960E-02 2.869E-02  7.704E-04  -2.470  -3.356
   90.00 109.89 300.00 3998.61 2338.00  6.83653E-07 1.0506E-02 2.843E-02  1.022E-03  -2.449  -3.302
```

85.00	110.02	300.00	4031.72	2351.70	1.24965E-06	5.6452E-03	2.705E-02	1.170E-03	-2.390	-3.343
80.00	110.14	300.00	4064.50	2365.40	1.99868E-06	3.9741E-03	2.661E-02	1.255E-03	-2.398	-3.355
75.00	110.26	300.00	4096.96	2379.00	2.37089E-06	5.9076E-03	2.893E-02	1.227E-03	-2.531	-3.245
70.00	110.38	300.00	4129.12	2392.50	2.09912E-06	9.3902E-03	2.896E-02	1.250E-03	-2.506	-3.301
65.00	110.50	300.00	4160.97	2405.90	1.88953E-06	1.2055E-02	2.799E-02	1.187E-03	-2.502	-3.240
60.00	110.62	300.00	4192.54	2419.30	1.89657E-06	1.3962E-02	2.577E-02	1.057E-03	-2.488	-3.148
55.00	110.73	300.00	4223.82	2432.50	1.96962E-06	1.8077E-02	2.055E-02	9.184E-04	-2.466	-3.094
50.00	110.85	300.00	4254.83	2445.70	2.27566E-06	2.3636E-02	1.362E-02	8.226E-04	-2.379	-3.094
45.00	110.97	300.00	4285.57	2458.80	3.00483E-06	2.5789E-02	9.457E-03	7.621E-04	-2.377	-3.079
40.00	111.08	300.00	4316.05	2471.80	3.48493E-06	2.4550E-02	7.800E-03	7.614E-04	-2.299	-3.098
35.00	111.20	300.00	4346.27	2484.70	3.38165E-06	2.4934E-02	7.336E-03	7.919E-04	-2.238	-3.148
30.00	111.31	300.00	4376.25	2497.60	3.03927E-06	2.7194E-02	7.276E-03	8.295E-04	-2.217	-3.212

4.3.2 Module Output Files

The Quick Dynamic 2-D Limb View module generates 3 ASCII output files; 2 informational files and an error file. The module also generates 2 binary output files; a background + structure radiance image file and a background radiance image file. These files have default file names, as noted below.

4.3.2.1 Informational File 1 “DYNAMIC.IN1” - (default file name)

<”DYNAMIC.IN1” file generated by the Quick Dynamic 2-D Limb View Module>

<Sample “DYNAMIC.IN1” file>

```
12345 =RANDOM NUMBER SEED
05-Dec-96 OUTPUT FROM THE QUICK DYNAMIC PROGRAM
NUMBER OF TRANSVERSE PIXELS SIMULATED=     256
NUMBER OF POINTS IN FFT USED TO SIMULATED TRANSVERSE=    1024
MAXIMUM NUMBER OF POINTS ALLOWED=    1024
BORE TANGENT HEIGHT(KM)=  8.0000E+01
TRANSVERSE SPACING(DEGREES)=  5.0000E-03
VERTICAL SPACING(DEGREES)=  5.0000E-03
FILE B - Day Limb Midlat. Summer 4 micron
BANDPASS AND RESOLUTION (CM-1)          2222.200  2500.200     2.000
EARTH RADIUS (KM) 6371.0000
TEMPERATURE STANDARD DEV MULTIPLIER        1.000
HORIZONTAL CORRELATION MULTIPLIER          1.000
VERTICAL CORRELATION MULTIPLIER            1.000
TEMP SPECTRAL INDICES (HORIZ/VERT)        -1.670    -3.000
SENSOR ZENITH ANGLES (DIVERGING FOV)      105.503   111.315
SENSOR ALTITUDE=  5.0000E+02
SMALLEST TANGENT HEIGHT SIMULATED=  5.3021E+01
NUMBER OF VERTICAL AR COEFFICIENTS=     6
NUMBER OF HORIZONTAL SHEETS USED FOR RELAXATION=   51
ESTIMATED LENGTH SCENE TRANSVERSE DIRECTION=  1.5292E+02 KM
ESTIMATED LENGTH SCENE VERTICAL DIRECTION=  1.5292E+02 KM
```

4.3.2.2 Informational File 2 "DYNAMIC.IN2" - (default file name)

<"DYNAMIC.IN2" file generated by the Quick Dynamic 2-D Limb View Module>

<Sample "DYNAMIC.IN2" file>

```
12345 =RANDOM NUMBER SEED
05-Dec-96 OUTPUT FROM THE QUICK DYNAMIC PROGRAM
  51 NUMBER OF HORIZONTAL SHEETS FOR RELAXATION
TIME(SECONDS) USED UNTIL FIRST 1-D PSD  2.2592E-01
TIME(SECONDS) FOR FIRST 2-D PSD  1.2134E-02
TIME(SECONDS) SO FAR USED IN THIS PROGRAM  2.3806E-01
```

4.3.2.3 Error File - "DYNAMIC.ERR" (default file name)

<"DYNAMIC.ERR file generated by the Quick Dynamic 2-D Limb View Module>

<Sample "DYNAMIC.ERR" file>

```
05-Dec-96 OUTPUT FROM THE QUICK DYNAMIC PROGRAM
```

4.3.2.4 Background + Structure Radiance Image File - "DYNAMIC.BS" (default file name)

This output file generated by the Quick Dynamic 2-D Limb View Module contains a synthetic array of deterministic background + stochastic structure radiance image data. The image file was written by FORTRAN unformatted write statements. The arrays were generated for an NYLOS x NZLOS pixel sensor, where NYLOS is the number of pixels in the transverse (Y-LOS) direction and NZLOS is the number of pixels in the vertical (Z-LOS) direction. Each record of binary data consists of a 2 dimensional I-J array of 32-bit words where I ranges from 1 to NYLOS and J ranges from 1 to NZLOS. The file is direct access and the data can be read with the following FORTRAN statement.

READ(NTAPE) ((DATA(I,J),I=1,NYLOS),J=1,NZLOS)

The first point in this array, DATA(1,1), represents the bottom left corner of the image. The last point in this array, DATA(NYLOS,NZLOS), represents the top right corner of the image. (row 1, column NZ) is the bottom right of the image and (row NY, column 1) is the top left of the image.

4.3.2.5 Background Radiance Image File - "DYNAMIC.BG" (default file name)

This output file generated by the Quick Dynamic 2-D Limb View Module contains a synthetic array of deterministic background radiance image data. The image file was written by FORTRAN unformatted write statements. The arrays were generated for an NYLOS x NZLOS pixel sensor, where NYLOS is the number of pixels in the transverse (Y-LOS) direction and NZLOS is the number of pixels in the vertical (Z-LOS) direction. Each record of binary data consists of a 2 dimensional I-J array of 32-bit words where I ranges from 1 to NYLOS and J ranges from 1 to NZLOS. The file is direct access and the data can be read with the following FORTRAN statement.

READ(NTAPE) ((DATA(I,J),I=1,NYLOS),J=1,NZLOS)

The first point in this array, DATA(1,1), represents the bottom left corner of the image. The last point in this array, DATA(NYLOS,NZLOS), represents the top right corner of the image. (row 1, column NZ) is the bottom right of the image and (row NY, column 1) is the top left of the image.

4.3.3 Sample Interactive Session

<Sample interactive session for the Quick Dynamic 2-D Limb View Module>

[sig]

```
PHILLIPS LABORATORY
GEOPHYSICS DIRECTORATE/GPOS
HANSCOM AFB, MA 01731

SHARC IMAGE GENERATOR (SIG)
V1.0A


CHOOSE METHOD TO PRODUCE RADIANCE STRUCTURE IMAGES
1 = LIMB VIEW
2 = NADIR
3 = OFF-NADIR
4 = EXIT
ENTER 1, 2, 3, OR 4
```

{1}

```
CHOOSE SPECIFIC LIMB VIEW APPROACH
1 = 3-D BRUTE FORCE APPROACH
2 = QUICK DYNAMIC APPROACH
3 = STRETCHED SPACE APPROACH
4 = RETURN TO PREVIOUS MENU
ENTER 1, 2, 3, OR 4
```

{2}

```
USING THE QUICK DYNAMIC APPROACH TO PRODUCE
RADIANCE STRUCTURE IMAGES

INPUT FILE NAMES ARE HARDWIRED (DYNAMIC.INP & DYNAMIC.PRM)

1 = CREATE NEW INPUT FILES
2 = USE/EDIT OLD INPUT FILES
3 = EXECUTE PROGRAM WITH OLD INPUT FILES
4 = RETURN TO PREVIOUS MENU
ENTER 1, 2, 3, OR 4
```

{1}

```
QUICK DYNAMIC SCENE GENERATION

EXISTING SHARC 4.0 OUTPUT FILE (REQUIRED)

1 = SHARCLC.DAT
    (SHARC 4.0 RADIANCE PARAMETER FILE)->CORR. L, PSD SLOPE, SIGMA

ENTER 1 TO MODIFY FILE NAME OR
      0 TO CONTINUE
```

{1}

```
SPECIFY FULL PATH AND FILE NAME, I.E., /DIREC/SHARCLC.DAT

OR, IF FILE RESIDES IN THE CURRENT DIRECTORY,

SPECIFY JUST THE FILE NAME, I.E., SHARCLC.DAT
```

{SIGTST.2D}

```
READING SHARC 4.0 RADIANCE PARAMETER OUTPUT FILE

SHARC FILE WAS READ SUCCESSFULLY

PRESS ENTER TO CONTINUE
```

{ENTER}

```
QUICK DYNAMIC SCENE GENERATION

USES 1D FFT FOR HORIZONTAL SIMULATION & DYNAMIC AR FOR VERTICAL SIMULATION.

MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: DYNAMIC.INP & DYNAMIC.PRM)

1 =         12345 5 DIGIT RANDOM SEED NUMBER
2 =           256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
3 =          1024 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
5 =           256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
6 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
7 = 1.400000E+02 BORE TANGENT ALTITUDE (KM)
8 =             6 NUMBER OF VERTICAL AR COEFFICIENTS
9 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{2}

```
ITEM  2
ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE


          2 < RANGE <    8192
            =       =

CURRENT VALUE =    256

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =    256
```

{0}

```
THE SIZE OF THE OUTPUT DATA BASE =    262144. BYTES,
DEFINED BY ITEM2*ITEM5*4, WHERE,

      256 = (ITEM 2)  ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
      256 = (ITEM 5)  ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
 QUICK DYNAMIC SCENE GENERATION

 USES 1D FFT FOR HORIZONTAL SIMULATION & DYNAMIC AR FOR VERTICAL SIMULATION.

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: DYNAMIC.INP & DYNAMIC.PRM)

 1 =        12345 5 DIGIT RANDOM SEED NUMBER
 2 =          256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 3 =         1024 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
 4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 5 =          256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 6 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 7 = 1.400000E+02 BORE TANGENT ALTITUDE (KM)
 8 =            6 NUMBER OF VERTICAL AR COEFFICIENTS
 9 =           51 NUMBER OF VERTICAL FILTER RELAXATION VALUES

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{3}

```
ITEM  3
NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE

THE NUMBER IS USED IN A FAST FOURIER TRANSFORM WHICH WILL
RUN FASTER IF THE NUMBER IS EQUAL TO SOME POWER OF 2. ALSO,
THE LARGER THE NUMBER, THE MORE ACCURATE THE REPRESENTAION.

          2 < RANGE <    8192
            =       =

CURRENT VALUE =   1024

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =   1024
```

{0}

```
 QUICK DYNAMIC SCENE GENERATION

 USES 1D FFT FOR HORIZONTAL SIMULATION & DYNAMIC AR FOR VERTICAL SIMULATION.

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: DYNAMIC.INP & DYNAMIC.PRM)

 1 =         12345 5 DIGIT RANDOM SEED NUMBER
 2 =           256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 3 =          1024 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
 4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 5 =           256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 6 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 7 = 1.400000E+02 BORE TANGENT ALTITUDE (KM)
 8 =             6 NUMBER OF VERTICAL AR COEFFICIENTS
 9 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{7}

```
ITEM  7
BORE TANGENT ALTITUDE (KM)


            30. < RANGE <    250.
                =       =

CURRENT VALUE = 1.400000E+02

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE = 1.400000E+02
```

{80}

```
 QUICK DYNAMIC SCENE GENERATION

 USES 1D FFT FOR HORIZONTAL SIMULATION & DYNAMIC AR FOR VERTICAL SIMULATION.

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: DYNAMIC.INP & DYNAMIC.PRM)

 1 =         12345 5 DIGIT RANDOM SEED NUMBER
 2 =           256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 3 =          1024 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
 4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 5 =           256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 6 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 7 = 8.000000E+01 BORE TANGENT ALTITUDE (KM)
 8 =             6 NUMBER OF VERTICAL AR COEFFICIENTS
 9 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{0}

```
QUICK DYNAMIC SCENE GENERATION

PROGRAM INPUT PARAMETERS (HARDWIRED FILE NAMES: DYNAMIC.INP & DYNAMIC.PRM)

 1 =          12345 5 DIGIT RANDOM SEED NUMBER
 2 =            256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 3 =           1024 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
 4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 5 =            256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 6 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 7 = 8.000000E+01 BORE TANGENT ALTITUDE (KM)
 8 =              6 NUMBER OF VERTICAL AR COEFFICIENTS
 9 =             51 NUMBER OF VERTICAL FILTER RELAXATION VALUES

ENTER 2 TO MAKE FURTHER MODIFICATIONS
      1 TO GENERATE BACKUP INPUT MENU FILES (OPTIONAL)
      0 TO CONTINUE
```

{1}

```
SPECIFY FULL PATH NAME FOR BACKUP INPUT MENU FILES (E.G. /DIR1/DIR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY .INP & .PRM BACKUP INPUT MENU FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (DYNAMIC2)
```

{ENTER}

```
BACKUP INPUT MENU FILE(S) ALREADY EXIST:
DYNAMIC2.INP
DYNAMIC2.PRM

ENTER 0 TO INPUT A DIFFERENT BACKUP FILE NAME OR
      1 IF FILE NAME IS ACCEPTABLE
```

{1}

```
QUICK DYNAMIC SCENE GENERATION

DEFAULT OUTPUT FILE NAMES

DYNAMIC.IN1   (INFORMATIONAL 1)
DYNAMIC.IN2   (INFORMATIONAL 2)
DYNAMIC.ERR   (ERRORS)
DYNAMIC.BS    (BACKGROUND + STRUCTURE RADIANCE IMAGE FILE)
DYNAMIC.BG    (BACKGROUND RADIANCE IMAGE FILE)

SPECIFY FULL PATH NAME FOR PROGRAM OUPUT FILES (E.G. /DR1/DR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY THE OUTPUT FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (DYNAMIC)
```

{ENTER}

```
QUICK DYNAMIC SCENE GENERATION

INDICATE DESIRED ACTION

1 = MAKE FURTHER MODIFICATIONS

2 = CREATE INPUT MENU FILES, COMPILE/EXECUTE PROGRAM, & EXIT

3 = CREATE INPUT MENU FILES AND EXIT

4 = EXIT WITH NO CHANGES

ENTER 1, 2, 3, OR 4
```

{2}

```
WARNING: DO NOT INITIATE ANOTHER QUICK DYNAMIC APPLICATION
         UNTIL THIS QUICK DYNAMIC SUBMISSION RUNS TO
         COMPLETION.

THE INPUT MENU FILES HAVE BEEN CREATED.
DYNAMIC.INP
DYNAMIC.PRM

THE BACKUP INPUT MENU FILES HAVE ALSO BEEN CREATED.
DYNAMIC2.INP
DYNAMIC2.PRM
```

4.4 Fast "Stretched Space" 2-D Limb View Module - "stretch.f" (hardwired file name)

4.4.1 Module Input Files

The Fast "Stetched Space" 2-D Limb View module requires 2 ASCII input files; a menu data file and a parameter file. They can be saved as backup files for future use (refer to Section 4.4.3). The module also requires 1 binary input file, a SHARC 4.0 radiance parameter output file. The menu data and parameter files have hardwired file names, and the SHARC 4.0 radiance parameter output file has a default file name, as noted below.

4.4.1.1 Menu Data File - "STRETCH.INP" (hardwired file name)

<"STRETCH.INP" file required for the Fast "Stretched Space" 2-D Limb View Module>

<Sample "STRETCH.INP" file>

```
SIGTST.2D
STRETCH.IN1
STRETCH.IN2
STRETCH.IN3
STRETCH.ERR
STRETCH.BS
STRETCH.BG
```

```
       12345 5 DIGIT RANDOM SEED NUMBER
1.666667E+00 SLOPE OF THE TRANSVERSE 1-D PSD
3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD
         256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
         256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
8.000000E+01 BORE TANGENT ALTITUDE (KM)
          51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
           6 NUMBER OF VERTICAL AR COEFFICIENTS (-1 => FT METHOD)
          -1 NUMBER OF TRANSVERSE AR COEFFICIENTS (-1 => FT METHOD)
```

4.4.1.2 Parameter File - "STRETCH.PRM" (hardwired file name)

<"STRETCH.PRM" file required for the Fast "Stretched Space" 2-D Limb View Module>

<Sample "STRETCH.PRM" file>

```
PARAMETER (NUMVMAX=                    256)
PARAMETER (NUMH1MAX=                    256)
PARAMETER (NUMHMAX=                    256)
PARAMETER (NARMAX=                      6)
PARAMETER (MAXONEV=                    20)
PARAMETER (NUMRDMAX=                    35)
```

4.4.1.3 SHARC 4.0 Radiance Parameter Output File - "SHARCLC.DAT" (default file name)

<"SHARCLC.DAT" file required for the Fast "Stretched Space" 2-D Limb View Module>

<Sample "SHARCLC.DAT" file>

```
FILE B - Day Limb Midlat. Summer 4 micron
BANDPASS AND RESOLUTION (CM-1)            2222.200  2500.200     2.000
EARTH RADIUS (KM)                         6371.000
TEMPERATURE STANDARD DEV MULTIPLIER          1.000
HORIZONTAL CORRELATION MULTIPLIER            1.000
VERTICAL CORRELATION MULTIPLIER              1.000
TEMP SPECTRAL INDICES (HORIZ/VERT)          -1.670    -3.000
SENSOR ZENITH ANGLES (DIVERGING FOV)       105.503   111.315
SENSOR ALTITUDE (KM)                       500.000
TANGENT  ZENITH TARGET RANGE   IMAGE PL MEAN        SIGMA/MEAN CORR ANGLE (RADIAN)   SPECTRAL INDEX
HT       ANGLE  HT             RANGE    RAD (W/SR)             (HORIZ)    (VERT)     (HORIZ) (VERT)
  250.00 105.50 300.00 2651.80 1836.60  4.07328E-12 3.9616E-02 9.563E-02  6.400E-03  -2.501  -3.210
  240.00 105.81 300.00 2764.95 1872.20  6.33058E-12 4.3953E-02 9.246E-02  6.080E-03  -2.496  -3.215
  230.00 106.12 300.00 2871.08 1907.20  9.94061E-12 4.7073E-02 8.942E-02  5.759E-03  -2.491  -3.221
  220.00 106.41 300.00 2971.51 1941.50  1.58227E-11 4.9526E-02 8.655E-02  5.424E-03  -2.490  -3.231
  210.00 106.71 300.00 3067.21 1975.10  2.56381E-11 5.1402E-02 8.352E-02  5.079E-03  -2.486  -3.246
  200.00 106.99 300.00 3158.87 2008.10  4.24055E-11 5.2627E-02 8.027E-02  4.727E-03  -2.481  -3.255
  190.00 107.28 300.00 3247.02 2040.60  7.19352E-11 5.3223E-02 7.676E-02  4.362E-03  -2.475  -3.262
  180.00 107.56 300.00 3332.07 2072.40  1.26024E-10 5.3199E-02 7.279E-02  3.970E-03  -2.467  -3.271
  170.00 107.83 300.00 3414.35 2103.80  2.30451E-10 5.2578E-02 6.843E-02  3.553E-03  -2.456  -3.284
  160.00 108.10 300.00 3494.15 2134.60  4.48156E-10 5.1356E-02 6.391E-02  3.115E-03  -2.465  -3.314
  150.00 108.37 300.00 3571.69 2165.00  8.76742E-10 4.7279E-02 5.929E-02  2.694E-03  -2.445  -3.319
```

```
145.00 108.50 300.00 3609.68 2180.00  1.39434E-09 4.7641E-02 5.749E-02  2.274E-03  -2.500  -3.195
140.00 108.63 300.00 3647.17 2194.90  2.15135E-09 4.6115E-02 5.461E-02  2.066E-03  -2.500  -3.233
135.00 108.76 300.00 3684.18 2209.70  3.53631E-09 4.4695E-02 5.122E-02  1.808E-03  -2.498  -3.217
130.00 108.89 300.00 3720.74 2224.30  6.04537E-09 4.2836E-02 4.766E-02  1.592E-03  -2.487  -3.254
125.00 109.02 300.00 3756.86 2238.90  1.14341E-08 4.1242E-02 4.387E-02  1.327E-03  -2.509  -3.243
120.00 109.14 300.00 3792.55 2253.30  2.37069E-08 3.9609E-02 3.941E-02  1.108E-03  -2.489  -3.298
115.00 109.27 300.00 3827.84 2267.70  4.74483E-08 3.0106E-02 3.709E-02  9.495E-04  -2.488  -3.256
110.00 109.40 300.00 3862.73 2281.90  7.84997E-08 1.8822E-02 3.336E-02  9.542E-04  -2.378  -3.363
105.00 109.52 300.00 3897.24 2296.10  1.21145E-07 1.9395E-02 3.043E-02  6.708E-04  -2.436  -3.151
100.00 109.65 300.00 3931.39 2310.20  1.97023E-07 1.9703E-02 2.835E-02  5.855E-04  -2.418  -3.332
 95.00 109.77 300.00 3965.17 2324.10  3.63771E-07 1.6960E-02 2.869E-02  7.704E-04  -2.470  -3.356
 90.00 109.89 300.00 3998.61 2338.00  6.83653E-07 1.0506E-02 2.843E-02  1.022E-03  -2.449  -3.302
 85.00 110.02 300.00 4031.72 2351.70  1.24965E-06 5.6452E-03 2.705E-02  1.170E-03  -2.390  -3.343
 80.00 110.14 300.00 4064.50 2365.40  1.99868E-06 3.9741E-03 2.661E-02  1.255E-03  -2.398  -3.355
 75.00 110.26 300.00 4096.96 2379.00  2.37089E-06 5.9076E-03 2.893E-02  1.227E-03  -2.531  -3.245
 70.00 110.38 300.00 4129.12 2392.50  2.09912E-06 9.3902E-03 2.896E-02  1.250E-03  -2.506  -3.301
 65.00 110.50 300.00 4160.97 2405.90  1.88953E-06 1.2055E-02 2.799E-02  1.187E-03  -2.502  -3.240
 60.00 110.62 300.00 4192.54 2419.30  1.89657E-06 1.3962E-02 2.577E-02  1.057E-03  -2.488  -3.148
 55.00 110.73 300.00 4223.82 2432.50  1.96962E-06 1.8077E-02 2.055E-02  9.184E-04  -2.466  -3.094
 50.00 110.85 300.00 4254.83 2445.70  2.27566E-06 2.3636E-02 1.362E-02  8.226E-04  -2.379  -3.094
 45.00 110.97 300.00 4285.57 2458.80  3.00483E-06 2.5789E-02 9.457E-03  7.621E-04  -2.377  -3.079
 40.00 111.08 300.00 4316.05 2471.80  3.48493E-06 2.4550E-02 7.800E-03  7.614E-04  -2.299  -3.098
 35.00 111.20 300.00 4346.27 2484.70  3.38165E-06 2.4934E-02 7.336E-03  7.919E-04  -2.238  -3.148
 30.00 111.31 300.00 4376.25 2497.60  3.03927E-06 2.7194E-02 7.276E-03  8.295E-04  -2.217  -3.212
```

4.4.2 Module Output Files

The Fast “Stretched Space” 2-D Limb View module generates 4 ASCII output files; 3 informational files and an error file. The module also generates 2 binary output files; a background + structure radiance image file and a background radiance image file. These files have default file names, as noted below.

4.4.2.1 Informational File 1 - “STRETCH.IN1” (default file name)

<”STRETCH.IN1” file generated by the Fast “Stretched Space” 2-D Limb View Module>

<Sample “STRETCH.IN1” file>

```
 12345 =RANDOM NUMBER SEED
 05-Dec-96 OUTPUT FROM THE FAST "STRETCHED SPACE" 2-D LIMB VIEW PROGRAM
  1.666666984558E+00 SLOPE OF PSD TRANSVERSE DIRECTION
  3.000000000000E+00 SLOPE OF PSD VERTICAL DIRECTION
       256 NUMBER OF PIXELS TRANSVERSE TO THE LINE OF SIGHT
       256 NUMBER OF VERTICAL PIXELS
 BORE HEIGHT(KM)=  8.0000E+01
 TRANSVERSE SPACING(DEGREES)=  5.0000E-03
 VERTICAL SPACING(DEGREES)=  5.0000E-03
FILE B - Day Limb Midlat. Summer 4 micron
BANDPASS AND RESOLUTION (CM-1)            2222.200
EARTH RADIUS (KM)                         6371.000
TEMPERATURE STANDARD DEV MULTIPLIER          1.000
HORIZONTAL CORRELATION MULTIPLIER            1.000
VERTICAL CORRELATION MULTIPLIER              1.000
TEMP SPECTRAL INDICES (HORIZ/VERT)          -1.670
SENSOR ZENITH ANGLES (DIVERGING FOV)       105.503
SENSOR ALTITUDE (KM)                       500.000
TANGENT  ZENITH TARGET RANGE   IMAGE PL MEAN
```

```
HT       ANGLE  HT              RANGE    RAD (W/SR)
 SMALLEST TANGENT HEIGHT=  5.3021E+01
  8.7266E-05 TRANSVERSE SPACING (RADIANS)
  1.0950E+02 LARGEST ZENITH ANGLE (DEGREES)
        51 =NRELAX WHICH IS THE NUMBER OF RELAXATION VALUES
 IF AR IS USED FOR VERTICAL PSD
         6 NUMBER OF AR COEFFICIENTS USED TO SIMULATE VERTICAL PSD IF LT 0 USE FFT
        -1 NUMBER OF AR COEFFICIENTS USED TO SIMULATE TRANSVERSE PSD IF LE 0 USE FFT
  1.1078E+02 =LOWEST SCALE HEIGHT
  1.0950E+02 =HIGHEST SCALE HEIGHT
  8.8709E-04 =LC USED IN SIMULATION
          ANGLE      STRETCH ANGLE  D(ANGLE)     ALTITUDE    D(ALTITUDE)
          110.7775    110.7775                   53.0210
          110.7725    110.7725     -0.004949     53.2274     0.206318
          110.7676    110.7675     -0.004949     53.4334     0.206005
          110.7626    110.7625     -0.004949     53.6397     0.206318
.
.
.
          109.5177    109.5175     -0.005051    105.0976     0.201759
          109.5126    109.5125     -0.005052    105.3081     0.210457
          109.5075    109.5075     -0.005052    105.5188     0.210770
          109.5025    109.5025     -0.005053    105.7293     0.210449
  2.8182E+02 =A FOR SCALE HEIGHT
```

4.4.2.2 Informational File 2 - "STRETCH.IN2" (default file name)

<"STRETCH.IN2" file generated bythe Fast "Stretched Space" 2-D Limb View Module>

<Sample "STRETCH.IN2" file>

```
 05-Dec-96 OUTPUT FROM THE FAST "STRETCHED SPACE" 2-D LIMB VIEW PROGRAM
  1.666666984558E+00 SLOPE OF PSD TRANSVERSE DIRECTION
  3.000000000000E+00 SLOPE OF PSD VERTICAL DIRECTION
       256 NUMBER OF PIXELS TRANSVERSE TO THE LINE OF SIGHT
       256 NUMBER OF VERTICAL PIXELS
 BORE HEIGHT(KM)=  8.0000E+01
 TRANSVERSE SPACING(DEGREES)=  5.0000E-03
 VERTICAL SPACING(DEGREES)=  5.0000E-03
 SMALLEST TANGENT HEIGHT=  5.3021E+01
  8.7266E-05 TRANSVERSE SPACING (RADIANS)
  1.0950E+02 LARGEST ZENITH ANGLE (DEGREES)
        51 =NRELAX WHICH IS THE NUMBER OF RELAXATION VALUES
 IF AR IS USED FOR VERTICAL PSD
         6 NUMBER OF AR COEFFICIENTS USED TO SIMULATE VERTICAL PSD IF LT 0 USE FFT
        -1 NUMBER OF AR COEFFICIENTS USED TO SIMULATE TRANSVERSE PSD IF LE 0 USE FFT
  5.3771E-01 TIME USED SO FAR IN SECONDS
 AFTER SIMULATING VERTICAL CORRELATED DATA
  6.1894E-01 TIME USED SO FAR IN SECONDS
 AFTER FFT'S FOR TRANSVERSE PIXELS
  1.1206E+00 TOTAL TIME IN SECONDS TO RUN PROGRAM
```

4.4.2.3 Informational File 3 - "STRETCH.IN3" (default file name)

<"STRETCH.IN3" file generated by the Fast "Stretched Space" 2-D Limb View Module>

<Sample "STRETCH.IN3" file>

```
05-Dec-96 OUTPUT FROM THE FAST "STRETCHED SPACE" 2-D LIMB VIEW PROGRAM
AR TO SIMULATE VERTICAL
 4.493229836226E-02
-1.436159849167E+00
 4.908091723919E-01
-3.341389819980E-02
 1.746849156916E-02
 8.226828649640E-04
 6.888682954013E-03
```

4.4.2.4 Error File - "STRETCH.ERR" (default file name)

<"STRETCH.ERR" file generated by the Fast "Stretched Space" 2-D Limb View Module>

<Sample "STRETCH.ERR" file>

05-Dec-96 OUTPUT FROM THE FAST "STRETCHED SPACE" 2-D LIMB VIEW PROGRAM

4.4.2.5 Background + Structure Radiance Image File - "STRETCH.BS" (default file name)

This output file generated by the Fast "Stretched Space" 2-D Limb View Module contains a synthetic array of deterministic background + stochastic structure radiance image data. The image file was written by FORTRAN unformatted write statements. The arrays were generated for an NYLOS x NZLOS pixel sensor, where NYLOS is the number of pixels in the transverse (Y-LOS) direction and NZLOS is the number of pixels in the vertical (Z-LOS) direction. Each record of binary data consists of a 2 dimensional I-J array of 32-bit words where I ranges from 1 to NYLOS and J ranges from 1 to NZLOS. The file is direct access and the data can be read with the following FORTRAN statement.

```
READ(NTAPE) ((DATA(I,J),I=1,NYLOS),J=1,NZLOS)
```

The first point in this array, DATA(1,1), represents the bottom left corner of the image. The last point in this array, DATA(NYLOS,NZLOS), represents the top right corner of

the image. (row 1, column NZ) is the bottom right of the image and (row NY, column 1) is the top left of the image.

4.4.2.6 Background Radiance Image File - "STRETCH.BG" (default file name)

This output file generated by the Fast "Stretched Space" 2-D Limb View Module contains a synthetic array of deterministic background radiance image data. The image file was written by FORTRAN unformatted write statements. The arrays were generated for an NYLOS x NZLOS pixel sensor, where NYLOS is the number of pixels in the transverse (Y-LOS) direction and NZLOS is the number of pixels in the vertical (Z-LOS) direction. Each record of binary data consists of a 2 dimensional I-J array of 32-bit words where I ranges from 1 to NYLOS and J ranges from 1 to NZLOS. The file is direct access and the data can be read with the following FORTRAN statement.

READ(NTAPE) ((DATA(I,J),I=1,NYLOS),J=1,NZLOS)

The first point in this array, DATA(1,1), represents the bottom left corner of the image. The last point in this array, DATA(NYLOS,NZLOS), represents the top right corner of the image. (row 1, column NZ) is the bottom right of the image and (row NY, column 1) is the top left of the image.

4.4.3 Sample Interactive Session

<Sample interactive session for the Fast "Stretched Space" 2-D Limb View Module>

[sig]

```
PHILLIPS LABORATORY
GEOPHYSICS DIRECTORATE/GPOS
HANSCOM AFB, MA 01731

SHARC IMAGE GENERATOR (SIG)
V1.0A


CHOOSE METHOD TO PRODUCE RADIANCE STRUCTURE IMAGES
1 = LIMB VIEW
2 = NADIR
3 = OFF-NADIR
4 = EXIT
ENTER 1, 2, 3, OR 4
```

{1}

```
CHOOSE SPECIFIC LIMB VIEW APPROACH
1 = 3-D BRUTE FORCE APPROACH
2 = QUICK DYNAMIC APPROACH
3 = STRETCHED SPACE APPROACH
4 = RETURN TO PREVIOUS MENU
ENTER 1, 2, 3, OR 4
```

{3}

```
USING THE STRETCHED SPACE APPROACH
TO PRODUCE RADIANCE STRUCTURE IMAGES

INPUT FILE NAMES ARE HARDWIRED (STRETCH.INP & STRETCH.PRM)

1 = CREATE NEW INPUT FILES
2 = USE/EDIT OLD INPUT FILES
3 = EXECUTE PROGRAM WITH OLD INPUT FILES
4 = RETURN TO PREVIOUS MENU
ENTER 1, 2, 3, OR 4
```

{1}

```
FAST "STRETCHED SPACE" SCENE GENERATION

EXISTING SHARC 4.0 OUTPUT FILE (REQUIRED)

1 = SHARCLC.DAT
    (SHARC 4.0 RADIANCE PARAMETER FILE)-->CORR. L, PSD SLOPE, SIGMA

ENTER 1 TO MODIFY FILE NAME OR
      0 TO CONTINUE
```

{1}

```
SPECIFY FULL PATH AND FILE NAME, I.E., /DIREC/SHARCLC.DAT

OR, IF FILE RESIDES IN THE CURRENT DIRECTORY,

SPECIFY JUST THE FILE NAME, I.E., SHARCLC.DAT
```

{SIGTST.2D}

```
READING SHARC 4.0 RADIANCE PARAMETER OUTPUT FILE

SHARC FILE WAS READ SUCCESSFULLY

PRESS ENTER TO CONTINUE
```

{ENTER}

```
 FAST "STRETCHED SPACE" SCENE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: STRETCH.INP & STRETCH.PRM)

 1 =         12345 5 DIGIT RANDOM SEED NUMBER
 2 = 1.666667E+00 SLOPE OF THE TRANSVERSE 1-D PSD
 3 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD
 4 =           256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 6 =           256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 1.400000E+02 BORE TANGENT ALTITUDE (KM)
 9 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
10 =             6 NUMBER OF VERTICAL AR COEFFICIENTS (-1 => FT METHOD)
11 =            -1 NUMBER OF TRANSVERSE AR COEFFICIENTS (-1 => FT METHOD)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{4}

```
ITEM  4
NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE


        2 < RANGE <    8192
          =       =

CURRENT VALUE =    256

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =    256
```

{0}

```
THE SIZE OF THE OUTPUT DATA BASE =    262144. BYTES,
DEFINED BY ITEM4*ITEM6*4, WHERE,

      256 = (ITEM 4)  NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
      256 = (ITEM 6)  NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
 FAST "STRETCHED SPACE" SCENE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: STRETCH.INP & STRETCH.PRM)

  1 =        12345 5 DIGIT RANDOM SEED NUMBER
  2 = 1.666667E+00 SLOPE OF THE TRANSVERSE 1-D PSD
  3 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD
  4 =          256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
  5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
  6 =          256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
  7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
  8 = 1.400000E+02 BORE TANGENT ALTITUDE (KM)
  9 =           51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
 10 =            6 NUMBER OF VERTICAL AR COEFFICIENTS (-1 => FT METHOD)
 11 =           -1 NUMBER OF TRANSVERSE AR COEFFICIENTS (-1 => FT METHOD)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{6}

```
ITEM  6
NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE


        2 < RANGE <    8192
          =       =

CURRENT VALUE =    256

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =    256
```

{0}

```
THE SIZE OF THE OUTPUT DATA BASE =     262144. BYTES,
DEFINED BY ITEM4*ITEM6*4, WHERE,

      256 = (ITEM 4)  NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
      256 = (ITEM 6)  NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
 FAST "STRETCHED SPACE" SCENE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: STRETCH.INP & STRETCH.PRM)

 1 =         12345 5 DIGIT RANDOM SEED NUMBER
 2 = 1.666667E+00 SLOPE OF THE TRANSVERSE 1-D PSD
 3 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD
 4 =           256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 6 =           256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 1.400000E+02 BORE TANGENT ALTITUDE (KM)
 9 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
10 =             6 NUMBER OF VERTICAL AR COEFFICIENTS (-1 => FT METHOD)
11 =            -1 NUMBER OF TRANSVERSE AR COEFFICIENTS (-1 => FT METHOD)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{8}

```
ITEM  8
BORE TANGENT ALTITUDE (KM)


            30. < RANGE <    250.
                =       =

CURRENT VALUE = 1.400000E+02

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE = 1.400000E+02
```

{80}

```
 FAST "STRETCHED SPACE" SCENE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: STRETCH.INP & STRETCH.PRM)

 1 =         12345 5 DIGIT RANDOM SEED NUMBER
 2 = 1.666667E+00 SLOPE OF THE TRANSVERSE 1-D PSD
 3 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD
 4 =           256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 6 =           256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 8.000000E+01 BORE TANGENT ALTITUDE (KM)
 9 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
10 =             6 NUMBER OF VERTICAL AR COEFFICIENTS (-1 => FT METHOD)
11 =            -1 NUMBER OF TRANSVERSE AR COEFFICIENTS (-1 => FT METHOD)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{9}

```
ITEM  9
NUMBER OF VERTICAL FILTER RELAXATION VALUES

THE VERTICAL RELAXATION VALUES ARE USED ONLY IF THE AUTO-
REGRESSION METHOD IS USED TO SIMULATE THE VERTICAL.

        10 < RANGE <    2000
           =        =

CURRENT VALUE =     51

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =     51
```

{0}

```
 FAST "STRETCHED SPACE" SCENE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: STRETCH.INP & STRETCH.PRM)

 1 =        12345 5 DIGIT RANDOM SEED NUMBER
 2 = 1.666667E+00 SLOPE OF THE TRANSVERSE 1-D PSD
 3 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD
 4 =          256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 6 =          256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 8.000000E+01 BORE TANGENT ALTITUDE (KM)
 9 =           51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
10 =            6 NUMBER OF VERTICAL AR COEFFICIENTS (-1 => FT METHOD)
11 =           -1 NUMBER OF TRANSVERSE AR COEFFICIENTS (-1 => FT METHOD)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{11}

```
ITEM 11
NUMBER OF TRANSVERSE AR COEFFICIENTS (-1 => FT METHOD)

THE TRANSVERSE AR RELAXATION CRITERIA USES A CYCLIC METHOD
(SEE MANUAL). HOWEVER, THIS IS NOT THE SUGGESTED METHOD.
THE FT METHOD IN THE TRANSVERSE DIRECTION IS THE PREFERRED
WAY TO PROCEED.

         2 < RANGE <      19
           =        =

CURRENT VALUE =     -1

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =     -1

     -1 TO USE FT METHOD
```

{0}

```
FAST "STRETCHED SPACE" SCENE GENERATION

MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: STRETCH.INP & STRETCH.PRM)

 1 =         12345 5 DIGIT RANDOM SEED NUMBER
 2 = 1.666667E+00 SLOPE OF THE TRANSVERSE 1-D PSD
 3 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD
 4 =           256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 6 =           256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 8.000000E+01 BORE TANGENT ALTITUDE (KM)
 9 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
10 =             6 NUMBER OF VERTICAL AR COEFFICIENTS (-1 => FT METHOD)
11 =            -1 NUMBER OF TRANSVERSE AR COEFFICIENTS (-1 => FT METHOD)

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{0}

```
FAST "STRETCHED SPACE" SCENE GENERATION

PROGRAM INPUT PARAMETERS (HARDWIRED FILE NAMES: STRETCH.INP & STRETCH.PRM)

 1 =         12345 5 DIGIT RANDOM SEED NUMBER
 2 = 1.666667E+00 SLOPE OF THE TRANSVERSE 1-D PSD
 3 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD
 4 =           256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 6 =           256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 8.000000E+01 BORE TANGENT ALTITUDE (KM)
 9 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
10 =             6 NUMBER OF VERTICAL AR COEFFICIENTS (-1 => FT METHOD)
11 =            -1 NUMBER OF TRANSVERSE AR COEFFICIENTS (-1 => FT METHOD)

ENTER 2 TO MAKE FURTHER MODIFICATIONS
      1 TO GENERATE BACKUP INPUT MENU FILES (OPTIONAL)
      0 TO CONTINUE
```

{1}

```
SPECIFY FULL PATH NAME FOR BACKUP INPUT MENU FILES (E.G. /DIR1/DIR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY .INP & .PRM BACKUP INPUT MENU FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (STRETCH2)
```

{ENTER}

```
BACKUP INPUT MENU FILE(S) ALREADY EXIST:
STRETCH2.INP
STRETCH2.PRM

ENTER 0 TO INPUT A DIFFERENT BACKUP FILE NAME OR
      1 IF FILE NAME IS ACCEPTABLE
```

{1}

```
FAST "STRETCHED SPACE" SCENE GENERATION

DEFAULT OUTPUT FILE NAMES

STRETCH.IN1   (INFORMATIONAL 1)
STRETCH.IN2   (INFORMATIONAL 2)
STRETCH.IN3   (INFORMATIONAL 3)
STRETCH.ERR   (ERRORS)
STRETCH.BS    (BACKGROUND + STRUCTURE RADIANCE IMAGE FILE)
STRETCH.BG    (BACKGROUND RADIANCE IMAGE FILE)

SPECIFY FULL PATH NAME FOR PROGRAM OUPUT FILES (E.G. /DR1/DR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY THE OUTPUT FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (STRETCH)
```

{ENTER}

```
FAST "STRETCHED SPACE" SCENE GENERATION

INDICATE DESIRED ACTION

1 = MAKE FURTHER MODIFICATIONS

2 = CREATE INPUT MENU FILES, COMPILE/EXECUTE PROGRAM, & EXIT

3 = CREATE INPUT MENU FILES AND EXIT

4 = EXIT WITH NO CHANGES

ENTER 1, 2, 3, OR 4
```

{2}

```
WARNING: DO NOT INITIATE ANOTHER FAST STRETCHED SPACE
         APPLICATION UNTIL THIS FAST STRETCHED SPACE
         SUBMISSION RUNS TO COMPLETION.

THE INPUT MENU FILES HAVE BEEN CREATED.
STRETCH.INP
STRETCH.PRM

THE BACKUP INPUT MENU FILES HAVE ALSO BEEN CREATED.
STRETCH2.INP
STRETCH2.PRM
```

4.5 Nadir Module - “nadir.f” (hardwired file name)

4.5.1 Module Input Files

The Nadir module requires 2 ASCII input files; a menu data file and a parameter file. These files have hardwired file names, as noted below. They can be saved as backup files for future use (refer to section 4.5.3).

4.5.1.1 Menu Data File - "NADIR.INP" (hardwired file name)

<"NADIR.INP" file required for the Nadir Module>

<Sample "NADIR.INP" file>

```
NADIR.ERR
NADIR.INF
NADIR.DB
       12345 5 DIGIT RANDOM NUMBER SEED
5.000000E+02 SENSOR ALTITUDE (KM)
         256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN X DIRECTION
        1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN X DIR.
5.000000E-03 IFOV OF X PIXEL (DEG)
         256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN Y DIRECTION
        1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN Y DIR.
5.000000E-03 IFOV OF Y PIXEL (DEG)
3.000000E+01 SCENE ALTITUDE (KM)
1.700000E+00 1-D PSD SLOPE
8.460000E+00 CORRELATION LENGTH (KM)
4.740000E-08 STANDARD DEVIATION OF SCENE
```

4.5.1.2 Parameter File - "NADIR.PRM" (hardwired file name)

<"NADIR.PRM" file required for the Nadir Module>

<Sample "NADIR.PRM" file>

```
      PARAMETER (MAXNISC=               1024)
      PARAMETER (MAXX=               1024)
      PARAMETER (MAXY=               1024)
```

4.5.2 Module Output Files

The Nadir module generates 2 ASCII output files; an informational file and an error file. The module also generates 1 binary output file; a structure radiance image file These files have default file names, as noted below.

4.5.2.1 Informational File - "NADIR.INF" (default file name)

<"NADIR.INF" file generated by the Nadir Module>

<Sample "NADIR.INF" file>

```
THIS IS OUTPUT FROM NADIR PROGRAM05-Dec-96
```

```
ALTITUDE OF SENSOR=    5.0000E+02 KM
FINAL SCENE IS    256 BY    256 PIXELS
INITIAL SCENE IS  1024 BY  1024 PIXELS
IFOV OF X,Y PIXELS=  5.0000E-03  5.0000E-03
ALTITUDE SCENE=  3.0000E+01 KM
2-D NONSEPARABLE ISOTROPIC MODEL
NADIR
NUX=  3.5000E-01 LCX=  8.4600E+00
SIMULATE SIGMA FOR RADIANCE=  4.7400E-08 OR SIGMA**2=  2.2468E-15
PSD SLOPE(X)=  1.7000E+00 PSD SLOPE(Y)=  1.7000E+00
DISTANCE COVERED BY FINAL SCENE X DIRECTION=  1.0500E+01 KM
DISTANCE COVERED BY INITIAL SCENE X DIRECTION=  4.2001E+01 KM
AVERAGE DISTANCE BETWEEN X SCENE PIXELS=  4.1017E-02 (KM)
DISTANCE COVERED BY FINAL SCENE Y DIRECTION=  1.0500E+01 KM
DISTANCE COVERED BY INITIAL SCENE Y DIRECTION=  4.2001E+01 KM
AVERAGE DISTANCE BETWEEN Y SCENE PIXELS=  4.1017E-02 (KM)
12345 =RANDOM NUMBER SEED
SIGMA**2 OF SPECIFIED SIGMA=  2.2468E-15
TRAPEZOIDAL RULE INTEGRATION PSD=  2.3596E-15
CHECK SIMULATED SIGMA**2 IN INITIAL SCENE=  1.7487E-15
SIGMA**2 IN STORED SIMULATED SCENE=  1.2467E-15
   RANGE OF VALUES -7.3678E-08 THRU  3.9857E-08
```

4.5.2.2 Error File - "NADIR.ERR" (default file name)

<"NADIR.ERR" file generated by the Nadir Module>

<Sample "NADIR.ERR" file>

```
THIS IS OUTPUT FROM NADIR PROGRAM05-Dec-96
```

4.5.2.3 Structure Radiance Image File - "NADIR.DB" (default file name)

This output file, generated by the Nadir program module, contains a synthetic array of stochastic structure radiance image data. The image file was written by FORTRAN unformatted write statements. The arrays were generated for an NXLOS x NYLOS pixel sensor, where NXLOS is the number of pixels in the (X-LOS) direction and NYLOS is the number of pixels in the transverse (Y-LOS) direction. Each record of binary data consists of a 2 dimensional I-J array of 32-bit words where I ranges from 1 to NYLOS and J ranges from 1 to NXLOS. The file is direct access and the data can be read with the following FORTRAN statement.

READ(NTAPE) ((DATA(I,J),I=1,NYLOS),J=1,NXLOS)

The first point in this array, DATA(1,1), represents the bottom left corner of the image. The last point in this array, DATA(NYLOS,NXLOS), represents the top right corner of the image. (row 1, column NY) is the bottom right of the image and (row NY, column 1) is the top left of the image.

4.5.3 Sample Interactive Session

<Sample interactive session for the Nadir Module>

[sig]

```
PHILLIPS LABORATORY
GEOPHYSICS DIRECTORATE/GPOS
HANSCOM AFB, MA 01731

SHARC IMAGE GENERATOR (SIG)
V1.0A


CHOOSE METHOD TO PRODUCE RADIANCE STRUCTURE IMAGES
1 = LIMB VIEW
2 = NADIR
3 = OFF-NADIR
4 = EXIT
ENTER 1, 2, 3, OR 4
```

{2}

```
USING THE NADIR APPROACH TO PRODUCE
RADIANCE STRUCTURE IMAGES

INPUT FILE NAMES ARE HARDWIRED (NADIR.INP & NADIR.PRM)

1 = CREATE NEW INPUT FILES
2 = USE/EDIT OLD INPUT FILES
3 = EXECUTE PROGRAM WITH OLD INPUT FILES
4 = RETURN TO PREVIOUS MENU
ENTER 1, 2, 3, OR 4
```

{1}

```
 NADIR RADIANCE IMAGE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: NADIR.INP & NADIR.PRM)

 1 =         12345 5 DIGIT RANDOM NUMBER SEED
 2 = 5.000000E+02 SENSOR ALTITUDE (KM)
 3 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN X DIRECTION
 4 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN X DIR.
 5 = 5.000000E-03 IFOV OF X PIXEL (DEG)
 6 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN Y DIRECTION
 7 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN Y DIR.
 8 = 5.000000E-03 IFOV OF Y PIXEL (DEG)
 9 = 3.000000E+01 SCENE ALTITUDE (KM)
10 = 1.700000E+00 1-D PSD SLOPE
11 = 8.460000E+00 CORRELATION LENGTH (KM)
12 = 4.740000E-08 STANDARD DEVIATION OF SCENE

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{3}

```
ITEM  3
ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN X DIRECTION


         2 < RANGE <    8192
           =        =

CURRENT VALUE =    256

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =    256
```

{0}

```
THE SIZE OF THE OUTPUT DATA BASE =    262144. BYTES,
DEFINED BY ITEM3*ITEM6*4, WHERE,

      256 = (ITEM 3) ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN X DIRECTION
      256 = (ITEM 6) ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN Y DIRECTION

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
 NADIR RADIANCE IMAGE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: NADIR.INP & NADIR.PRM)

  1 =         12345 5 DIGIT RANDOM NUMBER SEED
  2 = 5.000000E+02 SENSOR ALTITUDE (KM)
  3 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN X DIRECTION
  4 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN X DIR.
  5 = 5.000000E-03 IFOV OF X PIXEL (DEG)
  6 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN Y DIRECTION
  7 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN Y DIR.
  8 = 5.000000E-03 IFOV OF Y PIXEL (DEG)
  9 = 3.000000E+01 SCENE ALTITUDE (KM)
 10 = 1.700000E+00 1-D PSD SLOPE
 11 = 8.460000E+00 CORRELATION LENGTH (KM)
 12 = 4.740000E-08 STANDARD DEVIATION OF SCENE

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{4}

```
ITEM  4
NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN X DIR.

THE NUMBER IS USED IN A FAST FOURIER TRANSFORM WHICH WILL
RUN FASTER IF THE NUMBER IS EQUAL TO SOME POWER OF 2. ALSO,
THE LARGER THE NUMBER, THE MORE ACCURATE THE REPRESENTATION.

         2 < RANGE <   32768
           =        =

CURRENT VALUE =   1024

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =   1024
```

{0}

```
 NADIR RADIANCE IMAGE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: NADIR.INP & NADIR.PRM)

  1 =         12345 5 DIGIT RANDOM NUMBER SEED
  2 = 5.000000E+02 SENSOR ALTITUDE (KM)
  3 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN X DIRECTION
  4 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN X DIR.
  5 = 5.000000E-03 IFOV OF X PIXEL (DEG)
  6 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN Y DIRECTION
  7 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN Y DIR.
  8 = 5.000000E-03 IFOV OF Y PIXEL (DEG)
  9 = 3.000000E+01 SCENE ALTITUDE (KM)
 10 = 1.700000E+00 1-D PSD SLOPE
 11 = 8.460000E+00 CORRELATION LENGTH (KM)
 12 = 4.740000E-08 STANDARD DEVIATION OF SCENE

 ENTER # OF ITEM TO MODIFY OR
       0 TO CONTINUE
```

{6}

```
 ITEM   6
 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN Y DIRECTION


          2 < RANGE <    8192
            =        =

 CURRENT VALUE =    256

 ENTER NEW VALUE OR
       0 FOR DEFAULT VALUE =    256
```

{0}

```
 THE SIZE OF THE OUTPUT DATA BASE =    262144. BYTES,
 DEFINED BY ITEM3*ITEM6*4, WHERE,

       256 = (ITEM 3) ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN X DIRECTION
       256 = (ITEM 6) ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN Y DIRECTION

 ENTER 0 TO INPUT A DIFFERENT VALUE OR
       1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
 NADIR RADIANCE IMAGE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: NADIR.INP & NADIR.PRM)

  1 =         12345 5 DIGIT RANDOM NUMBER SEED
  2 = 5.000000E+02 SENSOR ALTITUDE (KM)
  3 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN X DIRECTION
  4 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN X DIR.
  5 = 5.000000E-03 IFOV OF X PIXEL (DEG)
  6 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN Y DIRECTION
  7 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN Y DIR.
  8 = 5.000000E-03 IFOV OF Y PIXEL (DEG)
  9 = 3.000000E+01 SCENE ALTITUDE (KM)
 10 = 1.700000E+00 1-D PSD SLOPE
 11 = 8.460000E+00 CORRELATION LENGTH (KM)
 12 = 4.740000E-08 STANDARD DEVIATION OF SCENE

 ENTER # OF ITEM TO MODIFY OR
       0 TO CONTINUE
```

{7}

```
ITEM  7
NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN Y DIR.

THE NUMBER IS USED IN A FAST FOURIER TRANSFORM WHICH WILL
RUN FASTER IF THE NUMBER IS EQUAL TO SOME POWER OF 2. ALSO,
THE LARGER THE NUMBER, THE MORE ACCURATE THE REPRESENTATION.

         2 < RANGE <   32768
           =       =

CURRENT VALUE =   1024

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =   1024
```

{0}

```
 NADIR RADIANCE IMAGE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: NADIR.INP & NADIR.PRM)

  1 =         12345 5 DIGIT RANDOM NUMBER SEED
  2 = 5.000000E+02 SENSOR ALTITUDE (KM)
  3 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN X DIRECTION
  4 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN X DIR.
  5 = 5.000000E-03 IFOV OF X PIXEL (DEG)
  6 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN Y DIRECTION
  7 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN Y DIR.
  8 = 5.000000E-03 IFOV OF Y PIXEL (DEG)
  9 = 3.000000E+01 SCENE ALTITUDE (KM)
 10 = 1.700000E+00 1-D PSD SLOPE
 11 = 8.460000E+00 CORRELATION LENGTH (KM)
 12 = 4.740000E-08 STANDARD DEVIATION OF SCENE

 ENTER # OF ITEM TO MODIFY OR
       0 TO CONTINUE
```

{0}

```
NADIR RADIANCE IMAGE GENERATION

PROGRAM INPUT PARAMETERS (HARDWIRED FILE NAMES: NADIR.INP & NADIR.PRM)

 1 =         12345 5 DIGIT RANDOM NUMBER SEED
 2 = 5.000000E+02 SENSOR ALTITUDE (KM)
 3 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN X DIRECTION
 4 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN X DIR.
 5 = 5.000000E-03 IFOV OF X PIXEL (DEG)
 6 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN Y DIRECTION
 7 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN Y DIR.
 8 = 5.000000E-03 IFOV OF Y PIXEL (DEG)
 9 = 3.000000E+01 SCENE ALTITUDE (KM)
10 = 1.700000E+00 1-D PSD SLOPE
11 = 8.460000E+00 CORRELATION LENGTH (KM)
12 = 4.740000E-08 STANDARD DEVIATION OF SCENE

ENTER 2 TO MAKE FURTHER MODIFICATIONS
      1 TO GENERATE BACKUP INPUT MENU FILES (OPTIONAL)
      0 TO CONTINUE
```

{1}

```
SPECIFY FULL PATH NAME FOR BACKUP INPUT MENU FILES (E.G. /DIR1/DIR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY .INP & .PRM BACKUP INPUT MENU FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (NADIR2)
```

{ENTER}

```
BACKUP INPUT MENU FILE(S) ALREADY EXIST:
NADIR2.INP
NADIR2.PRM

ENTER 0 TO INPUT A DIFFERENT BACKUP FILE NAME OR
      1 IF FILE NAME IS ACCEPTABLE
```

{1}

```
NADIR RADIANCE IMAGE GENERATION

DEFAULT OUTPUT FILE NAMES

NADIR.ERR   (ERRORS)
NADIR.INF   (INFORMATIONAL)
NADIR.DB    (STRUCTURE RADIANCE IMAGE FILE)

SPECIFY FULL PATH NAME FOR PROGRAM OUTPUT FILES (E.G. /DIR1/DIR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY THE OUTPUT FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (NADIR)
```

{ENTER}

```
NADIR RADIANCE IMAGE GENERATION

INDICATE DESIRED ACTION

1 = MAKE FURTHER MODIFICATIONS

2 = CREATE INPUT MENU FILES, COMPILE/EXECUTE PROGRAM, & EXIT

3 = CREATE INPUT MENU FILES AND EXIT

4 = EXIT WITH NO CHANGES

ENTER 1, 2, 3, OR 4
```

{2}

```
WARNING: DO NOT INITIATE ANOTHER NADIR APPLICATION UNTIL
         THIS NADIR SUBMISSION RUNS TO COMPLETION.

THE INPUT MENU FILES HAVE BEEN CREATED.
NADIR.INP
NADIR.PRM

THE BACKUP INPUT MENU FILES HAVE ALSO BEEN CREATED.
NADIR2.INP
NADIR2.PRM
```

4.6 Off-Nadir/Off-Vertical Module - "offnadir.f" (hardwired file name)

4.6.1 Module Input Files

The Off-Nadir/Off-Vertical module requires 2 ASCII input files; a menu data file and a parameter file. They can be saved as backup files for future use (refer to Section 4.6.3). The module also requires 1 binary input file, a SHARC 4.0 radiance parameter output file. The menu data and parameter files have hardwired file names, and the SHARC 4.0 radiance parameter output file has a default file name, as noted below.

4.6.1.1 Menu Data File - "OFFNADR.INP" (hardwired file name)

<"OFFNADR.INP" file required for the Off-Nadir/Off-Vertical Module>

<Sample "OFFNADR.INP" file>

```
SIGTSTDN.2D
OFFNADR.IN1
OFFNADR.IN2
OFFNADR.ERR
OFFNADR.SEC
OFFNADR.BS
OFFNADR.BG
       12345 5 DIGIT RANDOM SEED NUMBER
```

```
          256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
          256 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
         1024 NUMBER OF POINTS IN FFT ALONG THE LOS
          256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 1.550000E+02 BORE ZENITH ANGLE (DEG)
            6 NUMBER OF VERTICAL AR COEFFICIENTS
           51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
```

4.6.1.2 Parameter File - "OFFNADR.PRM" (hardwired file name)

<"OFFNADR.PRM" file required for the Off-Nadir/Off-Vertical Module>

<Sample "OFFNADR.PRM" file>

```
PARAMETER (NUMH1MAX=                256)
PARAMETER (NUMH2MAX=               1024)
PARAMETER (NUMHMAX=               1024)
PARAMETER (NUMCOEFVMAX=                 6)
PARAMETER (NALIASMAX=                21)
PARAMETER (NUMRDMAX=                43)
```

4.6.1.3 SHARC 4.0 Radiance Parameter Output File - "SHARCLC.DAT" (default file name)

<"SHARCLC.DAT" file required for the Off-Nadir/Off-Vertical Module>

<Sample "SHARCLC.DAT" file>

```
FILE B - Off-Nadir Day
BANDPASS AND RESOLUTION (CM-1)              2222.200  2500.200     2.000
EARTH RADIUS (KM)                           6371.000
TEMPERATURE STANDARD DEV MULTIPLIER            1.000
HORIZONTAL CORRELATION MULTIPLIER              1.000
VERTICAL CORRELATION MULTIPLIER                1.000
TEMP SPECTRAL INDICES (HORIZ/VERT)            -1.670    -3.000
SENSOR ZENITH ANGLES (DIVERGING FOV)         154.330   155.670
SENSOR ALTITUDE (KM)                         500.000
TANGENT  ZENITH TARGET RANGE    IMAGE PL MEAN         SIGMA/MEAN CORR ANGLE (RADIAN)    SPECTRAL INDEX
HT       ANGLE  HT              RANGE    RAD (W/SR)              (HORIZ)    (VERT)      (HORIZ) (VERT)
-3394.57 154.33  30.00  525.97  525.23  9.85644E-07 4.8238E-02 1.765E-02  6.197E-03  -1.825  -2.965
-3397.82 154.36  30.00  525.82  525.07  9.85503E-07 4.8241E-02 1.765E-02  6.202E-03  -1.825  -2.964
-3401.06 154.39  30.00  525.68  524.92  9.85363E-07 4.8245E-02 1.766E-02  6.207E-03  -1.825  -2.963
-3404.30 154.42  30.00  525.53  524.77  9.85224E-07 4.8248E-02 1.766E-02  6.212E-03  -1.825  -2.962
-3408.63 154.46  30.00  525.34  524.61  9.85036E-07 4.8253E-02 1.766E-02  6.219E-03  -1.825  -2.960
-3411.88 154.49  30.00  525.20  524.46  9.84896E-07 4.8256E-02 1.767E-02  6.224E-03  -1.825  -2.959
-3415.12 154.52  30.00  525.06  524.31  9.84756E-07 4.8260E-02 1.767E-02  6.229E-03  -1.825  -2.961
-3418.37 154.55  30.00  524.91  524.15  9.84617E-07 4.8263E-02 1.767E-02  6.234E-03  -1.824  -2.956
-3421.62 154.58  30.00  524.77  524.00  9.84478E-07 4.8267E-02 1.768E-02  6.239E-03  -1.824  -2.955
-3425.95 154.62  30.00  524.58  523.85  9.84292E-07 4.8271E-02 1.768E-02  6.246E-03  -1.824  -2.952
-3429.20 154.65  30.00  524.44  523.70  9.84154E-07 4.8275E-02 1.768E-02  6.251E-03  -1.824  -2.951
-3432.45 154.68  30.00  524.30  523.55  9.84016E-07 4.8278E-02 1.768E-02  6.256E-03  -1.824  -2.950
-3435.71 154.71  30.00  524.15  523.39  9.83878E-07 4.8282E-02 1.769E-02  6.261E-03  -1.824  -2.948
-3438.96 154.74  30.00  524.01  523.24  9.83740E-07 4.8285E-02 1.769E-02  6.266E-03  -1.823  -2.948
```

-3443.30	154.78	30.00	523.82	523.09	9.83556E-07	4.8290E-02	1.769E-02	6.273E-03	-1.823	-2.945
-3446.55	154.81	30.00	523.68	522.94	9.83419E-07	4.8294E-02	1.770E-02	6.278E-03	-1.823	-2.944
-3449.81	154.84	30.00	523.54	522.79	9.83281E-07	4.8297E-02	1.770E-02	6.283E-03	-1.823	-2.943
-3453.07	154.87	30.00	523.40	522.64	9.83144E-07	4.8301E-02	1.770E-02	6.288E-03	-1.823	-2.944
-3456.32	154.90	30.00	523.26	522.49	9.83008E-07	4.8304E-02	1.771E-02	6.294E-03	-1.823	-2.941
-3460.67	154.94	30.00	523.08	522.34	9.82826E-07	4.8309E-02	1.771E-02	6.300E-03	-1.823	-2.938
-3463.93	154.97	30.00	522.94	522.19	9.82688E-07	4.8312E-02	1.771E-02	6.306E-03	-1.822	-2.937
-3467.19	155.00	30.00	522.80	522.05	9.82553E-07	4.8316E-02	1.771E-02	6.311E-03	-1.822	-2.937
-3470.45	155.03	30.00	522.66	521.90	9.82417E-07	4.8319E-02	1.772E-02	6.316E-03	-1.822	-2.935
-3473.71	155.06	30.00	522.52	521.75	9.82282E-07	4.8323E-02	1.772E-02	6.321E-03	-1.822	-2.933
-3478.06	155.10	30.00	522.33	521.60	9.82100E-07	4.8327E-02	1.772E-02	6.328E-03	-1.822	-2.933
-3481.33	155.13	30.00	522.19	521.45	9.81966E-07	4.8331E-02	1.773E-02	6.333E-03	-1.821	-2.930
-3484.59	155.16	30.00	522.06	521.31	9.81830E-07	4.8334E-02	1.773E-02	6.339E-03	-1.821	-2.929
-3487.86	155.19	30.00	521.92	521.16	9.81695E-07	4.8338E-02	1.773E-02	6.344E-03	-1.821	-2.927
-3491.12	155.22	30.00	521.78	521.01	9.81561E-07	4.8341E-02	1.773E-02	6.349E-03	-1.821	-2.927
-3495.48	155.26	30.00	521.60	520.87	9.81382E-07	4.8346E-02	1.774E-02	6.356E-03	-1.821	-2.924
-3498.75	155.29	30.00	521.46	520.72	9.81247E-07	4.8349E-02	1.774E-02	6.361E-03	-1.821	-2.920
-3502.01	155.32	30.00	521.32	520.57	9.81114E-07	4.8353E-02	1.774E-02	6.366E-03	-1.821	-2.921
-3505.28	155.35	30.00	521.19	520.43	9.80980E-07	4.8356E-02	1.775E-02	6.372E-03	-1.820	-2.920
-3508.55	155.38	30.00	521.05	520.28	9.80847E-07	4.8360E-02	1.775E-02	6.377E-03	-1.820	-2.919
-3512.92	155.42	30.00	520.87	520.14	9.80670E-07	4.8364E-02	1.775E-02	6.384E-03	-1.820	-2.917
-3516.19	155.45	30.00	520.73	519.99	9.80537E-07	4.8368E-02	1.776E-02	6.389E-03	-1.820	-2.916
-3519.46	155.48	30.00	520.60	519.85	9.80404E-07	4.8371E-02	1.776E-02	6.394E-03	-1.820	-2.913
-3522.73	155.51	30.00	520.46	519.70	9.80272E-07	4.8375E-02	1.776E-02	6.400E-03	-1.820	-2.913
-3526.01	155.54	30.00	520.33	519.56	9.80139E-07	4.8378E-02	1.776E-02	6.405E-03	-1.819	-2.911
-3530.38	155.58	30.00	520.15	519.41	9.79964E-07	4.8383E-02	1.777E-02	6.412E-03	-1.819	-2.910
-3533.65	155.61	30.00	520.01	519.27	9.79832E-07	4.8386E-02	1.777E-02	6.417E-03	-1.819	-2.908
-3536.93	155.64	30.00	519.88	519.13	9.79700E-07	4.8390E-02	1.777E-02	6.423E-03	-1.819	-2.907
-3540.21	155.67	30.00	519.74	518.98	9.79569E-07	4.8393E-02	1.778E-02	6.428E-03	-1.819	-2.906

4.6.2 Module Output Files

The Off-Nadir/Off-Vertical module generates 4 ASCII output files; 2 informational files, an error file, and a run time file. The module also generates 2 binary output files; a background + structure radiance database file and a background radiance database file. These files have default file names, as noted below.

4.6.2.1 Informational File 1 - "OFFNADR.IN1" (default file name)

<"OFFNADR.IN1" file generated by the Off-Nadir/Off-Vertical Module>

<Sample "OFFNADR.IN1" file>

```
12345 =RANDOM NUMBER SEED
06-Dec-96 OUTPUT FROM THE OFFNADIR PROGRAM
1024 NUMBER OF POINTS SIMULATED ALONG LOS
  51 NUMBER OF SHEETS FOR RELAXATION
 7.9090E-05 SPACING ALONG LINE OF SIGHT IN 3-D SCENE (RADIANS)
```

4.6.2.2 Informational File 2 - "OFFNADR.IN2" (default file name)

<"OFFNADR.IN2" file generated by the Off-Nadir/Off-Vertical Module>

<Sample "OFFNADR.IN2" file>

```
12345 =RANDOM NUMBER SEED
06-Dec-96 OUTPUT FROM THE OFFNADIR PROGRAM
ZENITH ANGLE AT BORE.DIRECTION=  1.5500E+02 DEGREES
FILE B - Off-Nadir Day
BANDPASS AND RESOLUTION (CM-1)          2222.200  2500.200     2.000
EARTH RADIUS (KM)= 6371.0000
TEMPERATURE STANDARD DEV MULTIPLIER        1.000
HORIZONTAL CORRELATION MULTIPLIER          1.000
VERTICAL CORRELATION MULTIPLIER            1.000
TEMP SPECTRAL INDICES (HORIZ/VERT)        -1.670    -3.000
SENSOR ZENITH ANGLES (DIVERGING FOV)     154.330   155.670
SENSOR ALTITUDE (KM)=  5.0000E+02
IFOV OF LOS PIXEL FOR SIMULALTION (RADIANS)=  7.9090E-05
IFOV OF VERTICAL PIXEL FOR SIMULATION (RADIANS)=  3.6880E-05
IFOV OF TRANSVERSE PIXEL FOR SIMULATION (RADIANS)=  8.7266E-05
BORE TANGENT ALTITUDE= -3.4672E+03
ALTITUDE FOR SCENE=  3.0000E+01 KM
ESTIMATED LOS DISTANCE=  5.2280E+02 KM
ESTIMATED LENGTH SCENE TRANSVERSE DIRECTION=  1.1680E+01 KM
ESTIMATED LENGTH SCENE VERTICAL DIRECTION=  4.9360E+00 KM
      256 NUMBER OF TRANSVERSE PIXELS IN SCENE
      256 NUMBER OF VERTICAL PIXELS IN SCENE
        6 NUMBER OF AR VERTICAL COEFFICIENTS
       51 NUMBER OF SHEETS FOR RELAXATION
      256 NUMBER OF POINTS IN FFT TRANSVERSE
     1024 NUMBER OF POINTS SIMULATED ALONG LOS
 7.9090E-05 SPACING ALONG LINE OF SIGHT IN 3-D SCENE (RADIANS)
TOTAL TIME FOR PROGRAM=  2.5431E+03 SECONDS
```

4.6.2.3 Error File - "OFFNADR.ERR" (default file name)

<"OFFNADR.ERR" file generated by the Off-Nadir/Off-Vertical Module>

<Sample "OFFNADR.ERR" file>

```
06-Dec-96 OUTPUT FROM THE OFFNADIR PROGRAM
```

4.6.2.4 Run Time File - "OFFNADR.SEC" (default file name)

<"OFFNADR.SEC" file generated by the Off-Nadir/Off-Vertical Module>

<Sample "OFFNADR.SEC" file>

```
 TIME(SECONDS) USED UNTIL FIRST 2-D PSD  2.5560E+02
 TIME(SECONDS) FOR FIRST 2-D PSD  4.4610E+00
 TIME(SECONDS) SO FAR USED IN THIS PROGRAM  2.6006E+02
 TIME SPENT FINISHING UP FIRST SHEET RESULT(SECONDS)  2.0142E-02
 TIME(SECONDS) SO FAR USED IN THIS PROGRAM  2.6008E+02
```

4.6.2.5 Background + Structure Radiance Image File - "OFFNADR.BS" (default file name)

This output file generated by the Off-Nadir/Off-Vertical module contains a synthetic array of deterministic background + stochastic structure radiance image data. The image file was written by FORTRAN unformatted write statements. The arrays were generated for an NYLOS x NZLOS pixel sensor, where NYLOS is the number of pixels in the transverse (Y-LOS) direction and NZLOS is the number of pixels in the vertical (Z-LOS) direction. Each record of binary data consists of a 2 dimensional I-J array of 32-bit words where I ranges from 1 to NYLOS and J ranges from 1 to NZLOS. The file is direct access and the data can be read with the following FORTRAN statement.

READ(NTAPE) ((DATA(I,J),I=1,NYLOS),J=1,NZLOS)

The first point in this array, DATA(1,1), represents the bottom left corner of the image. The last point in this array, DATA(NYLOS,NZLOS), represents the top right corner of the image. (row 1, column NZ) is the bottom right of the image and (row NY, column 1) is the top left of the image.

4.6.2.6 Background Radiance Image File - "OFFNADR.BG" (default file name)

This output file generated by the Off-Nadir/Off-Vertical module contains a synthetic array of deterministic background radiance image data. The image file was written by FORTRAN unformatted write statements. The arrays were generated for an NYLOS x NZLOS pixel sensor, where NYLOS is the number of pixels in the transverse (Y-LOS) direction and NZLOS is the number of pixels in the vertical (Z-LOS) direction. Each record of binary data consists of a 2 dimensional I-J array of 32-bit words where I ranges from 1 to NYLOS and J ranges from 1 to NZLOS. The file is direct access and the data can be read with the following FORTRAN statement.

READ(NTAPE) ((DATA(I,J),I=1,NYLOS),J=1,NZLOS)

The first point in this array, DATA(1,1), represents the bottom left corner of the image. The last point in this array, DATA(NYLOS,NZLOS), represents the top right corner of the image. (row 1, column NZ) is the bottom right of the image and (row NY, column 1) is the top left of the image.

4.6.3 Sample Interactive Session

<Sample interactive session for the Off-Nadir/Off-Vertical Module>

[sig]

```
PHILLIPS LABORATORY
GEOPHYSICS DIRECTORATE/GPOS
HANSCOM AFB, MA 01731

SHARC IMAGE GENERATOR (SIG)
V1.0A


CHOOSE METHOD TO PRODUCE RADIANCE STRUCTURE IMAGES
1 = LIMB VIEW
2 = NADIR
3 = OFF-NADIR
4 = EXIT
ENTER 1, 2, 3, OR 4
```

{3}

```
USING THE OFF-NADIR APPROACH TO PRODUCE
RADIANCE STRUCTURE IMAGES

INPUT FILE NAMES ARE HARDWIRED (OFFNADR.INP & OFFNADR.PRM)

1 = CREATE NEW INPUT FILES
2 = USE/EDIT OLD INPUT FILES
3 = EXECUTE PROGRAM WITH OLD INPUT FILES
4 = RETURN TO PREVIOUS MENU
ENTER 1, 2, 3, OR 4
```

{1}

```
OFF-NADIR SCENE GENERATION

EXISTING SHARC 4.0 OUTPUT FILE (REQUIRED)

1 = SHARCLC.DAT
    (SHARC 4.0 RADIANCE PARAMETER FILE)-->CORR. L, PSD SLOPE, SIGMA

ENTER 1 TO MODIFY FILE NAME OR
      0 TO CONTINUE
```

{1}

```
SPECIFY FULL PATH AND FILE NAME, I.E., /DIREC/SHARCLC.DAT

OR, IF FILE RESIDES IN THE CURRENT DIRECTORY,

SPECIFY JUST THE FILE NAME, I.E., SHARCLC.DAT
```

{SIGTSTDN.2D}

```
READING SHARC 4.0 RADIANCE PARAMETER OUTPUT FILE

SHARC FILE WAS READ SUCCESSFULLY

PRESS ENTER TO CONTINUE
```

{ENTER}

```
 OFF-NADIR SCENE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: OFFNADR.INP & OFFNADR.PRM)

 1 =         12345 5 DIGIT RANDOM SEED NUMBER
 2 =           256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 3 =           256 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
 4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 5 =          1024 NUMBER OF POINTS IN FFT ALONG THE LOS
 6 =           256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 1.550000E+02 BORE ZENITH ANGLE (DEG)
 9 =             6 NUMBER OF VERTICAL AR COEFFICIENTS
10 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{2}

```
ITEM  2
ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE


         2 ≤ RANGE ≤    8192

CURRENT VALUE =    256

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =    256
```

{0}

```
THE SIZE OF THE OUTPUT DATA BASE =    262144. BYTES,
DEFINED BY ITEM2*ITEM6*4, WHERE,

      256 = (ITEM 2)  ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
      256 = (ITEM 6)  ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
OFF-NADIR SCENE GENERATION

MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: OFFNADR.INP & OFFNADR.PRM)

 1 =          12345 5 DIGIT RANDOM SEED NUMBER
 2 =            256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 3 =            256 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
 4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 5 =           1024 NUMBER OF POINTS IN FFT ALONG THE LOS
 6 =            256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 1.550000E+02 BORE ZENITH ANGLE (DEG)
 9 =              6 NUMBER OF VERTICAL AR COEFFICIENTS
10 =             51 NUMBER OF VERTICAL FILTER RELAXATION VALUES

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{3}

```
ITEM  3
NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE

THE NUMBER IS USED IN A FAST FOURIER TRANSFORM WHICH WILL
RUN FASTER IF THE NUMBER IS EQUAL TO SOME POWER OF 2. ALSO,
THE LARGER THE NUMBER, THE MORE ACCURATE THE REPRESENTAION.

         2 < RANGE <    8192
           =       =

CURRENT VALUE =    256

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =    256
```

{0}

```
OFF-NADIR SCENE GENERATION

MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: OFFNADR.INP & OFFNADR.PRM)

 1 =          12345 5 DIGIT RANDOM SEED NUMBER
 2 =            256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 3 =            256 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
 4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 5 =           1024 NUMBER OF POINTS IN FFT ALONG THE LOS
 6 =            256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 1.550000E+02 BORE ZENITH ANGLE (DEG)
 9 =              6 NUMBER OF VERTICAL AR COEFFICIENTS
10 =             51 NUMBER OF VERTICAL FILTER RELAXATION VALUES

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{5}

```
ITEM  5
NUMBER OF POINTS IN FFT ALONG THE LOS

SINCE 2-D SCENE IS PROJECTED INTO 3-D SPACE, WE NEED TO CREATE
A PSEUDO-LOS WITH LOS SPACING.

THE NUMBER IS USED IN A FAST FOURIER TRANSFORM WHICH WILL
RUN FASTER IF THE NUMBER IS EQUAL TO SOME POWER OF 2. ALSO,
THE LARGER THE NUMBER, THE MORE ACCURATE THE REPRESENTAION.

         2 < RANGE <    8192
           =       =

CURRENT VALUE =   1024

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =   1024
```

{0}

```
 OFF-NADIR SCENE GENERATION

 MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: OFFNADR.INP & OFFNADR.PRM)

 1 =        12345 5 DIGIT RANDOM SEED NUMBER
 2 =          256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 3 =          256 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
 4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 5 =         1024 NUMBER OF POINTS IN FFT ALONG THE LOS
 6 =          256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 1.550000E+02 BORE ZENITH ANGLE (DEG)
 9 =            6 NUMBER OF VERTICAL AR COEFFICIENTS
10 =           51 NUMBER OF VERTICAL FILTER RELAXATION VALUES

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{6}

```
ITEM  6
ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE


         2 < RANGE <    8192
           =       =

CURRENT VALUE =    256

ENTER NEW VALUE OR
      0 FOR DEFAULT VALUE =    256
```

{0}

```
THE SIZE OF THE OUTPUT DATA BASE =     262144. BYTES,
DEFINED BY ITEM2*ITEM6*4, WHERE,

      256 = (ITEM 2)  ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
      256 = (ITEM 6)  ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE

ENTER 0 TO INPUT A DIFFERENT VALUE OR
      1 IF THIS VALUE IS ACCEPTABLE
```

{1}

```
OFF-NADIR SCENE GENERATION

MODIFY INPUT MENU DATA (HARDWIRED FILE NAMES: OFFNADR.INP & OFFNADR.PRM)

 1 =         12345 5 DIGIT RANDOM SEED NUMBER
 2 =           256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 3 =           256 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
 4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 5 =          1024 NUMBER OF POINTS IN FFT ALONG THE LOS
 6 =           256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 1.550000E+02 BORE ZENITH ANGLE (DEG)
 9 =             6 NUMBER OF VERTICAL AR COEFFICIENTS
10 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES

ENTER # OF ITEM TO MODIFY OR
      0 TO CONTINUE
```

{0}

```
OFF-NADIR SCENE GENERATION

PROGRAM INPUT PARAMETERS (HARDWIRED FILE NAMES: OFFNADR.INP & OFFNADR.PRM)

 1 =         12345 5 DIGIT RANDOM SEED NUMBER
 2 =           256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
 3 =           256 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
 4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
 5 =          1024 NUMBER OF POINTS IN FFT ALONG THE LOS
 6 =           256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
 7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
 8 = 1.550000E+02 BORE ZENITH ANGLE (DEG)
 9 =             6 NUMBER OF VERTICAL AR COEFFICIENTS
10 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES

ENTER 2 TO MAKE FURTHER MODIFICATIONS
      1 TO GENERATE BACKUP INPUT MENU FILES (OPTIONAL)
      0 TO CONTINUE
```

{1}

```
SPECIFY FULL PATH NAME FOR BACKUP INPUT MENU FILES (E.G. /DIR1/DIR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY .INP & .PRM BACKUP INPUT MENU FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (OFFNADR2)
```

{ENTER}

```
BACKUP INPUT MENU FILE(S) ALREADY EXIST:
OFFNADR2.INP
OFFNADR2.PRM

ENTER 0 TO INPUT A DIFFERENT BACKUP FILE NAME OR
      1 IF FILE NAME IS ACCEPTABLE
```

{1}

```
OFF-NADIR SCENE GENERATION

DEFAULT OUTPUT FILE NAMES

OFFNADR.IN1   (INFORMATIONAL 1)
OFFNADR.IN2   (INFORMATIONAL 2)
OFFNADR.ERR   (ERRORS)
OFFNADR.SEC   (RUN TIME)
OFFNADR.BS    (BACKGROUND + STRUCTURE RADIANCE IMAGE FILE)
OFFNADR.BG    (BACKGROUND RADIANCE IMAGE FILE)

SPECIFY FULL PATH NAME FOR PROGRAM OUPUT FILES (E.G. /DR1/DR2/)
OR PRESS ENTER FOR CURRENT DIRECTORY.
```

{ENTER}

```
SPECIFY THE OUTPUT FILE PREFIX
OR PRESS ENTER FOR DEFAULT PREFIX (OFFNADR)
```

{ENTER}

```
OFF-NADIR SCENE GENERATION

INDICATE DESIRED ACTION

1 = MAKE FURTHER MODIFICATIONS

2 = CREATE INPUT MENU FILES, COMPILE/EXECUTE PROGRAM, & EXIT

3 = CREATE INPUT MENU FILES AND EXIT

4 = EXIT WITH NO CHANGES

ENTER 1, 2, 3, OR 4
```

{2}

```
WARNING: DO NOT INITIATE ANOTHER OFF-NADIR APPLICATION
         UNTIL THIS OFF-NADIR SUBMISSION RUNS TO
         COMPLETION.

THE INPUT MENU FILES HAVE BEEN CREATED.
OFFNADR.INP
OFFNADR.PRM

THE BACKUP INPUT MENU FILES HAVE ALSO BEEN CREATED.
OFFNADR2.INP
OFFNADR2.PRM
```

APPENDIX A

AUTO-REGRESSION THEORY (Computational Details)

APPENDIX A

AUTO-REGRESSION THEORY (Computational Details)

This section is a brief review of autoregressive digital spectral estimation as presented by S. Lawrence Marple[1] and Steven M. Kay[2].

An autoregressive moving average (ARMA) model for a discrete spatial series, v(n), that approximates deterministic and stochastic processes can be represented by the filter linear difference equation:

$$\mathrm{v}(n) = -\sum_{j=1}^{p} a(j)\mathrm{v}(n-j) + \sum_{j=0}^{q} b(j)\varepsilon(n-j)$$

in which v(n) is the output sequence and $\varepsilon(n)$ a white noise input driving sequence. The $a(j)$ and $b(j)$ coefficients form the autoregressive and moving average portions of the ARMA model respectively. A z transform analysis of the difference equation shows that the ARMA power spectral density ($P_{ARMA}(k)$) is:

$$P_{ARMA}(k) = \Delta\mathrm{v}\sigma_w^2 \left|\frac{B(k)}{A(k)}\right|^2 \quad \text{for } -\infty \le k \le \infty$$

where k is the spatial frequency and where,

$$A(k) = 1 + \sum_{j=1}^{p} a(j)\exp(-2\pi ikj\Delta\mathrm{v})$$

and,

$$B(k) = 1 + \sum_{j=1}^{q} b(j)\exp(-2\pi ikj\Delta\mathrm{v}), \text{ with } b(0) = 1.$$

Here $\Delta\mathrm{v}$ is the sampling interval, σ_w^2 is the variance of the white noise process, and $i = \sqrt{-1}$. If all the moving average coefficients are zero, except $b(0) = 1$, then,

$$\mathrm{v}(n) = -\sum_{j=1}^{p} a(j)\mathrm{v}(n-j) + \varepsilon(n)$$

and the process is strictly autoregressive of order p. The autoregressive *PSD* becomes: $P_{AR}(k) = \dfrac{2\Delta\mathrm{v}\sigma_w^2}{|A(k)|^2} = 2\Delta\mathrm{v}\sum_{j=-\infty}^{\infty} r_{\mathrm{vv}}(j)\exp(-2\pi ikj\Delta\mathrm{v})$, for $0 \le k \le \infty$

where r_{vv} is the real and even autocorrelation sequence at j and σ_w^2 is the variance of $\varepsilon(n)$. The relationship between the autocorrelation sequence and the pure autoregressive model is:

---

[1]Marple, S.L., (1987) *Digital Spectral Analysis with Applications*, Chapter 6, Prentice-Hall, New Jersey.

[2]Kay, Steven M., (1988) *Modern Spectral Estimation, Theory & Application*, Prentice-Hall, New Jersey.

$$r_{vv}(m) = \begin{cases} -\sum_{j=1}^{p} a(j) r_{vv}(m-j) & \text{for } m > 0 \\ -\sum_{j=1}^{p} a(j) r_{vv}(-j) + \sigma_w^2 & \text{for } m = 0 \\ r_{vv}^*(-m) & \text{for } m < 0 \end{cases}$$

This expression may be evaluated for the $p+1$ lag indices $0 \le m \le p$ by:

$$\begin{pmatrix} r_{vv}(0) & r_{vv}(-1) & \cdots & r_{vv}(-p) \\ r_{vv}(1) & r_{vv}(0) & \cdots & r_{vv}(a(1)) \\ \vdots & \vdots & \ddots & \vdots \\ r_{vv}(p) & r_{vv}(p-1) & \cdots & r_{vv}(0) \end{pmatrix} \begin{pmatrix} 1 \\ a(1) \\ \vdots \\ a(p) \end{pmatrix} = \begin{pmatrix} \sigma_w^2 \\ 0 \\ \vdots \\ 0 \end{pmatrix}$$

This expression forms the autoregressive Yule-Walker equations. Given the autocorrelation sequence for lags 0 to *p*, the autoregressive coefficients may be found from the above. Since $r_{vv}(-k) = r_{vv}^*(k)$, the autocorrelation matrix is both Toeplitz and Hermitian. A standard "Levinson" algorithm that takes advantage of the Hermitian-Toeplitz matrix equation was employed to solve for the AR parameters. The same Yule-Walker equations also occur if we attempt to solve the problem: find the "best", in a least squares sense, set of equations that determine the coefficients that predict $\hat{v}$ from $\hat{v}(n) = -\sum_{j=1}^{p} a(j) v(n-j)$, where $\overline{(\hat{v}(n) - v(n))^2} = \sigma_w^2$. In summary, the Levinson recursion computes sets of coefficients $\{a_1(1), \sigma_1^2\}, \{a_2(1), a_2(2), \sigma_2^2\}, \cdots, \{a_p(1), a_p(2), \cdots, a_p(p), \sigma_p^2\}$ where the final set at order *p* is the desired solution of the Yule-Walker expressions. For the AR(*p*) process, $a_p(j) = a(j)$ for $j = 1, 2, 3, \cdots, p$ and σ_p^2 is the minimum prediction error, i.e. $\sigma_p^2 = \sigma_w^2 = \sigma_{\min}^2 = \xi[v^*[n](v[n] - \hat{v}[n])]$. The algorithm is initialized by:

$$a_1[1] = -\frac{r_{vv}[1]}{r_{vv}[0]}$$

$$\sigma_1^2 = \left(1 - |a_1[1]|^2\right) r_{vv}[0]$$

with the recursion for $j = 2, 3, \cdots p$ given by:

$$a_j[j] = -\frac{r_{vv}[j] + \sum_{\mu=1}^{j-1} a_{j-1}[\mu] r_{vv}[j-\mu]}{\sigma_{j-1}^2}$$

$$a_j[\eta] = a_{j-1}[\eta] + a_j[j] a_{j-1}^*[j-\eta] \quad \eta = 1, 2, \ldots, j-1$$

$$\sigma_j^2 = \left(1 - |a_j[j]|^2\right)\sigma_{j-1}^2$$

The $a_j[j]$ coefficients are known as reflection coefficients.

Line-Of-Sight PSD Truncation Correction

Since the 3-D constructed temperature fluctuation database has a finite and relatively large line-of-sight data spacing, a natural truncation of the line-of-sight power spectral density function must occur that would cause aliasing of the line-of-sight *PSD*'s for any particular realization. The specified temperature fluctuation database will have a horizontal transverse Nyquist frequency (k_{NY_t}), and a line-of-sight Nyquist frequency (k_{NY_ℓ}). Our treatment assumes the *PSD* = 0 beyond k_{NY_t}. Since energy exists between k_{NY_ℓ} and k_{NY_t}, aliasing must occur in the LOS direction. Consequently, computational "aliasing" of the line-of-sight *PSD*'s is added to the "theoretical" *PSD*'s by the following formulation. For an isotropic two-dimensional power density spectrum having frequencies k_t and k_ℓ, with Nyquist frequencies k_{NY_t} and k_{NY_ℓ}, the estimated power spectral density (PSD_e) is:

$$PSD_e(k_t,k_\ell) = PSD(k_t,k_\ell) + PSD(k_t,2k_{NY_\ell} - k_\ell) + PSD(k_t,2k_{NY_\ell} + k_\ell) + PSD(k_t,4k_{NY_\ell} - k_\ell) + PSD(k_t,4k_{NY_\ell} + k_\ell) + \cdots$$

until the second argument becomes greater than k_{NY_t}. Each term in the series on the right forms an aliasing branch. Two special cases apply.
At $k_\ell = 0$, $PSD_e(k_t,0) = PSD(k_t,0) + PSD(k_t,2k_{NY_\ell}) + PSD(k_t,4k_{NY_\ell}) + \cdots$.
And at $k_\ell = k_{NY_\ell}$, $PSD_e(k_t,k_{NY_\ell}) = PSD(k_t,k_{NY_\ell}) + PSD(k_t,3k_{NY_\ell}) + PSD(k_t,5k_{NY_\ell}) + \cdots$. Hence, the computation of $PSD_e(k_t,k_\ell)$ is the "theoretical" horizontal *PSD* that is used in construction of the simulated database. The above applies since the two-dimensional discrete Fourier Transform, $F(k_t,k_\ell)$, of a function $f(t,\ell)$ is: $F(k_t,k_\ell) = \sum_{j=0}^{N_t} \sum_{l=0}^{N_\ell} f(t_j,\ell_l) e^{-itk_t} e^{-i\ell k_\ell}$ $for\ 0 \le k_t, k_\ell \le \pi$, and since, $e^{-i\ell(2\pi - k_\ell)} = e^{i\ell k_\ell} = (e^{-i\ell k_\ell})^*$ and $e^{-i\ell(2\pi + k_\ell)} = e^{-i\ell k_\ell} = (e^{i\ell k_\ell})^*$. This implies that the $PSD(k_t, 2\pi - k_\ell)$ contributes to the *PSD*

of $f(t,\ell)$ at frequency k_t, k_ℓ and the $PSD(k_t, 2\pi + k_\ell)$ also contributes to the PSD of $f(t,\ell)$.

Rectangular Window Correction - Truncation of Autocorrelation Function

The horizontal two-dimensional discrete Fourier Transform used in the syntheses of the database results in a well-known rectangular window sampling effect. Assuming negligible truncation of the autocorrelation function in the line-of-sight direction, truncation in the transverse direction leads to side-lobe leakage of the frequency response function of the digitized rectangular window. In the transverse direction, the effects of leakage can be computed as the convolution of the "theoretical" $PSD(k_t, k_\ell)$ with the square of the magnitude of the frequency response of a digital sinc function. The magnitude of the digital sinc function resulting from sampling N values equally spaced by Δt in the transverse direction is: $|H(k_t)| = \left|\Delta t \dfrac{\sin(\pi k_t N \Delta t)}{\sin(\pi k_t \Delta t)}\right|$. This means the PSD, after accounting for leakage in the transverse direction, is the digital adjusted function, $PSD_{\otimes}(k_t, k_\ell)$ where, $PSD_{\otimes}(k_t, k_\ell) = \dfrac{1}{N\Delta t}\displaystyle\int_{k_t - k_{NY_t}}^{k_t + k_{NY_t}} PSD(k, k_\ell)(\Delta t)^2 \dfrac{\sin^2\left(\left(k_t - k\right)\pi N \Delta t\right)}{\sin^2\left(\left(k_t - k\right)\pi \Delta t\right)} dk$, and where we assume $PSD_{\otimes}(|k_t| > k_{NY_t}, k_\ell) = 0$. Normalizing so there is no change in the total energy, that is to say σ^2, we arrive at the "corrected" power spectral density function, $PSD^*(k_t, k_\ell)$. The normalization is necessary because the variance of the "continuous" power spectral density differs from the variance of the "discretized" power spectral density. The normalization depends on the continuous case variance $\sigma^2_{t,\ell}$ defined by $\sigma^2_{t,\ell} = \int_{-k_{NY_t}}^{k_{NY_t}} PSD(k, k_\ell) dk$, and also on the discrete case variance $\sigma^2_{\otimes,\ell}$ defined by $\sigma^2_{\otimes,\ell} = \dfrac{1}{N\Delta t} \displaystyle\sum_{k_t = -k_{NY_t}}^{k_{NY_t} - \frac{1}{N\Delta t}} PSD_{\otimes}(k_t, k_\ell)$ (with step size $\dfrac{1}{N\Delta t}$). The "corrected" PSD then becomes: $PSD^*(k_t, k_\ell) = \dfrac{\sigma^2_{t,\ell}}{\sigma^2_{\otimes,\ell}} \times PSD_{\otimes}(k_t, k_\ell)$. Accounting for the discretized windowing effect, the two-dimensional white noise spectrum should be multiplied by some value $A^*(k_t, k_\ell)$. Assuming negligible contribution from the truncation of the autocorrelation function in the line-of-sight direction, $A^*(k_t, k_\ell)$ is determined by: $A^*(k_t, k_\ell) = \sqrt{\dfrac{PSD^*(k_t, k_\ell)}{\Delta t \Delta \ell}}$, where Δt is the transverse spacing and $\Delta \ell$ is the LOS spacing. Using the expression for $A^*(k_t, k_\ell)$, a computational "correction" to each LOS frequency may be made to account for the windowing effect but such compu-

tation is prohibitively intensive. Instead, the following approximate scheme was devised.

Since by construction, $\frac{1}{N\Delta t}\int_{-k_{NY_t}}^{k_{NY_t}} |H(k)|^2 dk = 1$, the convolution theorem requires $\sum_{k_t}\sum_{k_\ell} A^{*^2}(k_t, k_\ell) = \sigma^2$. Observation of $A^*(k_t, k_\ell)$ indicates that the major sampling effect occurs for the $PSD(k_t, k_\ell)$ at the extrema $k_t = 0$. This implies that the "corrected" *PSD* closely follows the "theoretical" *PSD* for all the discrete frequencies except the zero frequency. In pursuit of avoiding the time-consuming convolution integral, an approximation was developed that modified the $PSD(k_t, k_\ell)$ at $k_t = 0$. The approximation was devised from the following reasoning. We wish for the variance of our simulation to equal a given value σ^2 but the actual value of the "uncorrected" simulated variance is equal to $\sum_{k_t}\sum_{k_\ell} A^2(k_t, k_\ell)$, where $A^2 = \frac{PSD_e(k_t, k_\ell)}{\Delta t \Delta \ell}$, and where $PSD_e(k_t, k_\ell)$ is the two-dimensional theoretical model with aliasing in the k_ℓ direction:

$$PSD_e(k_t, k_\ell) = PSD(k_t, k_\ell) + PSD(k_t, 2k_{NY_\ell} - k_\ell) + PSD(k_t, 2k_{NY_\ell} + k_\ell) + PSD(k_t, 4k_{NY_\ell} - k_\ell) + PSD(k_t, 4k_{NY_\ell} + k_\ell) + \cdots.$$

Thus, we wish to find a modified approximate value, $\hat{A}$, such that the theoretical variance, σ_t^2, is: $\sigma_t^2 = \sum_{k_t}\sum_{k_\ell} \hat{A}^2(k_t, k_\ell)$. As noted, with the extrema at $k_t = 0$, we set $\hat{A}(0, k_\ell)$ by the linear interpolation relation: $\hat{A}(0, k_\ell) = gA(0, k_\ell) + (1-g)A(k_t = 1, k_\ell)$, where $k_t = 1$ is the first non-zero LOS frequency value and we set all other $\underset{k_t \neq 0}{\hat{A}(k_t, k_\ell)} = A(k_t, k_\ell)$. Then it follows:

$\sigma_t^2 = \sum_{k_\ell}\left(gA(0, k_\ell) + (1-g)A(k_t = 1, k_\ell)\right)^2 + \sum_{k_t \neq 0}\sum_{k_\ell} A^2(k_t, k_\ell)$. Expanding, we find a quadratic expression for g, which is:

$$\begin{aligned}0 = {} & g^2 \sum_{k_\ell}\left(A^2(0, k_\ell) + A^2(k_t = 1, k_\ell) - 2A(0, k_\ell)A(k_t = 1, k_\ell)\right) \\ & + g\sum_{k_\ell}\left(2A(0, k_\ell)A(k_t = 1, k_\ell) - 2A^2(k_t = 1, k_\ell)\right) \\ & + \sum_{k_\ell} A^2(k_t = 1, k_\ell) + \sum_{k_t \neq 0}\sum_{k_\ell} A^2(k_t, k_\ell) - \sigma_t^2\end{aligned}$$

Analysis reveals a near power law relationship between g and $\frac{L_{ct}}{\Delta t}$.

APPENDIX B

TEST CASES

APPENDIX B

TEST CASES

The 2-D images in this manual were generated by an IDL program. This IDL program is available from J. Brown upon request.

Test Case A 3-D Temperature Structure Database Generation

The following menu lists the test parameters used in the generation of the 3-D Temperature Structure Database files, "TEMPS.DB1" and "TEMPS.DB2". These files were used as input by the Limb View Brute Force 3-D Integration program in the generation of the single scene and multiple scene test cases (Refer below to Test Case B).

```
NEW 3-D TEMPERATURE STRUCTURE (TS) DATABASE GENERATION

    INPUT PARAMETERS

   1 =         12345 5 DIGIT RANDOM NUMBER SEED
   2 = 6.371000E+03 RADIUS OF THE EARTH IN KILOMETERS FOR TS SIMULATION
   3 = 2.666667E+00 SLOPE OF THE HORIZONTAL 2-D PSD FOR TS SIMULATION
   4 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD FOR TS SIMULATION
   5 = 3.000000E+01 LOWEST ALTITUDE FOR TS SIMULATION IN KILOMETERS
   6 = 2.000000E-01 VERTICAL SPACING FOR TS SIMULATION IN KILOMETERS
   7 =          1101 NUMBER OF VERTICAL VALUES FOR TS SIMULATION
   8 =             6 NUMBER OF VERTICAL A.R. COEFFICIENTS FOR TS SIMULATION
   9 =            51 NUMBER OF ITERATIONS TO START TS SIMULATION PROCESS
  10 = 2.000000E-01 TRANSVERSE SPACING FOR TS SIMULATION (LOWEST ALT) KM
  11 =          1024 NUMBER OF TRANSVERSE VALUES FOR TS SIMULATION
  12 = 1.600000E+03 LENGTH ALONG LOS FOR TS SIMULATION (LOWEST ALT) KM
  13 =            64 NUMBER OF VALUES ALONG LOS FOR TS SIMULATION
  14 =           125 NUMBER OF CYCLES TO ACCOUNT FOR ALIASING ALONG LOS (NCA)
```

Test Case B Limb View Brute Force 3-D Integration

The two database files as generated from the previous menu (Test Case A - The 3-D Temperature Structure Database Generation) and the SHARC 4.0 output file, as noted below, were used as input in the Limb View 3-D Integration test cases.

1. Temperature Descriptor Database File: "TEMPS.DB1" (refer to Section 4.2.1.3)

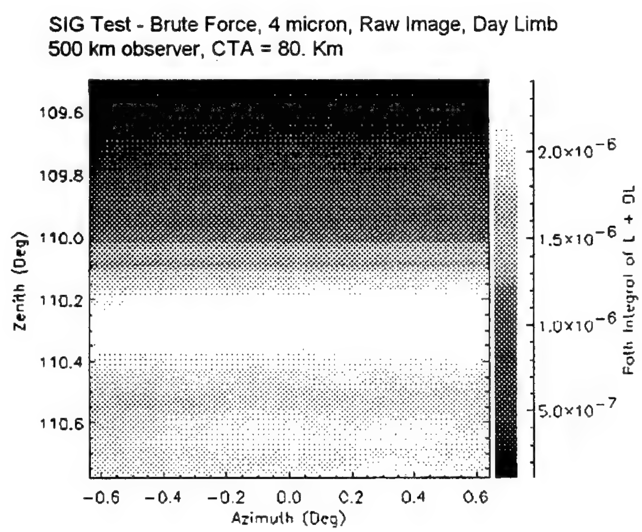
2. Temperature Structure Database File: "TEMPS.DB2" (refer to Section 4.2.1.4)

3. SHARC 4.0 Radiance Fluctuation Amplitude Output File: "SIGTST.3D".
   The default file name for the "SIGTST.3D" file is "SHARCFA.DAT" (refer to Section 4.2.1.5).

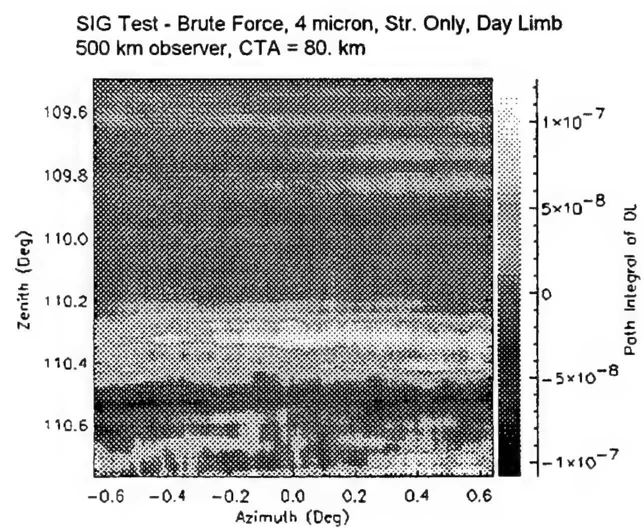
The following menu lists the test parameters used in the Limb View Brute Force 3-D Integration single scene test case.

```
LIMB VIEW BRUTE FORCE 3-D INTEGRATION      (SINGLE SCENE)

   INPUT PARAMETERS

  1 =              0 TEMPERATURE (0=SHARC DATA / 1=STANDARD ATMOSPHERIC MODEL)
  2 =            256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
  3 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
  4 =            256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
  5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
  6 = 8.000000E+01 BORE TANGENT ALTITUDE (BTA) IN KM
  7 = 8.000000E+01 MAXIMUM BORE TANGENT ALTITUDE (KM) [OBTAINED FROM BTA(S)]
```

Limb View Brute Force 3-D Integration (Single Scene Images)



Synthetic Background + Structure Image



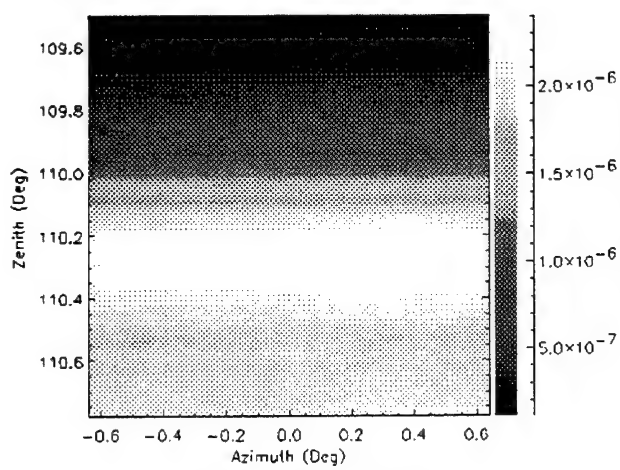
Synthetic Structure Image

The following menu lists the test parameters used in the Limb View Brute Force 3-D Integration multiple scene test case.

```
LIMB VIEW BRUTE FORCE 3-D INTEGRATION      (MULTIPLE SCENES)
   INPUT PARAMETERS

    1 =              0 TEMPERATURE (0=SHARC DATA / 1=STANDARD ATMOSPHERIC MODEL)
    2 =            256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
    3 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
    4 =            256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
    5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
    6 = 8.000000E+01 BORE TANGENT ALTITUDE (BTA) IN KM
    7 = 9.000000E+01 MAXIMUM BORE TANGENT ALTITUDE (KM) [OBTAINED FROM BTA(S)]

  BORE TANGENT ALTITUDES (MULTIPLE SCENES)
    1 =  80.00        2 =  85.00        3 =  90.00
```

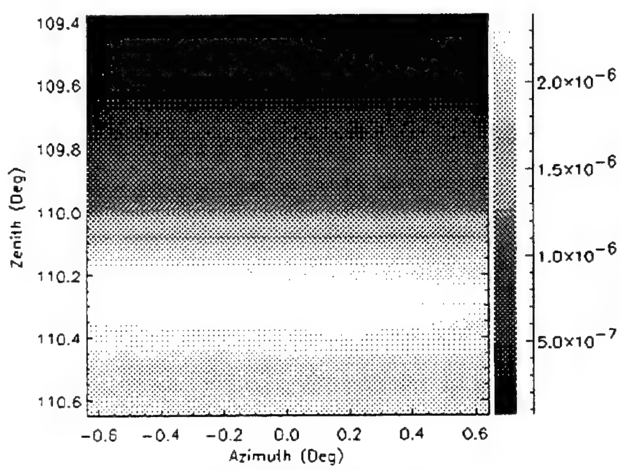
Limb View Brute Force 3-D Integration (Multiple Scene Images)
Common Point at Center of Scenes (80 km Common Altitude)

SIG Test - Brute Force, 4 micron, Raw Image, Day Limb
500 km observer, CTA = 80 km, CA = 80 km



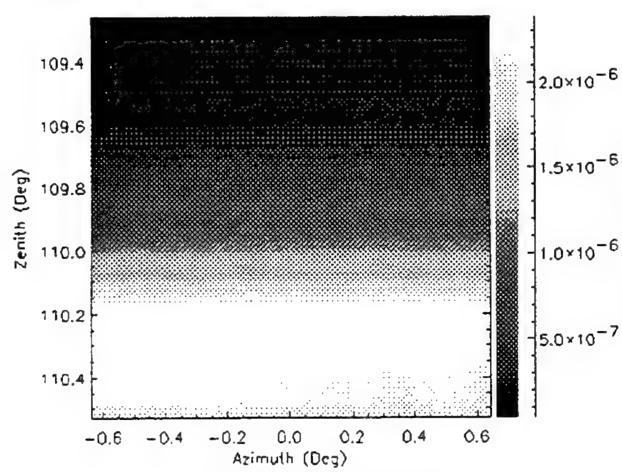
Center TA = 80 km

SIG Test - Brute Force, 4 micron, Raw Image, Day Limb
500 km observer, CTA = 85 km, CA = 80 km



Center TA = 85 km

SIG Test - Brute Force, 4 micron, Raw Image, Day Limb
500 km observer, CTA = 90 km, CA = 80 km

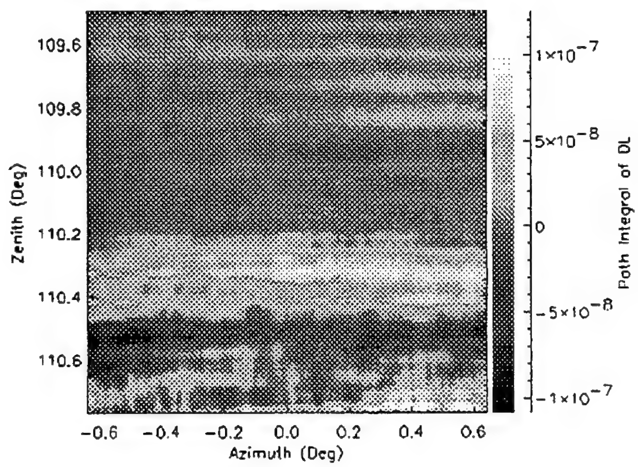


Center TA = 90 km

Synthetic Background + Structure Images

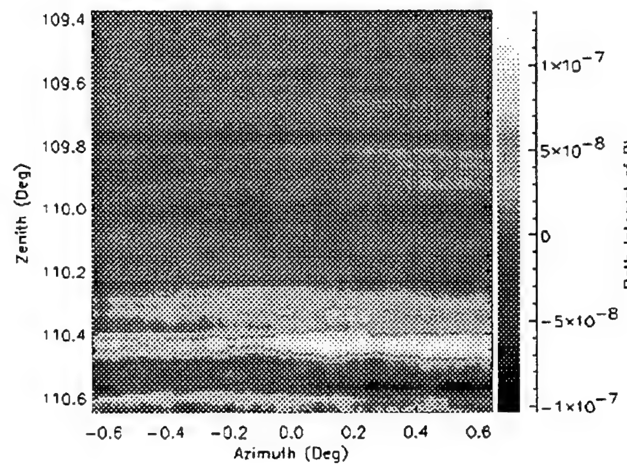
Limb View Brute Force 3-D Integration (Multiple Scene Images)
Common Point at Center of Scenes (80 km Common Altitude)

SIG Test - Brute Force, 4 micron, Str. Only, Day Limb
500 km observer, CTA = 80 km, CA = 80 km



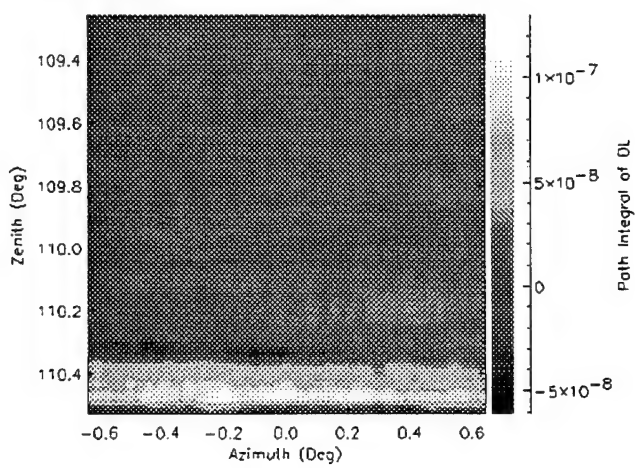
Center TA = 80 km

SIG Test - Brute Force, 4 micron, Str. Only, Day Limb
500 km observer, CTA = 85 km, CA =80 km



Center TA = 85 km

SIG Test - Brute Force, 4 micron, Str. Only, Day Limb
500 km observer, CTA = 90 km, CA = 80 km



Center TA = 90 km

Synthetic Structure Images

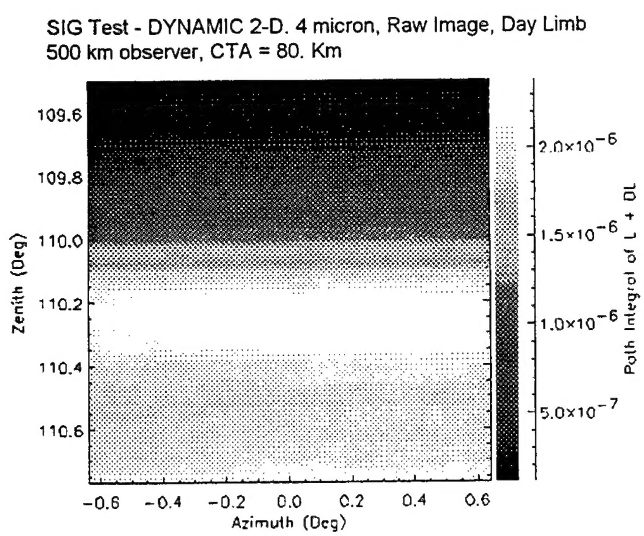
Test Case C **Quick Dynamic 2-D Limb View**

The SHARC 4.0 Radiance Parameter output file, "SIGTST.2D", was used in the Quick Dynamic 2-D Limb View test case. The default file name for the "SIGTST.2D" file is "SHARCLC.DAT" (refer to Section 4.3.1.3).

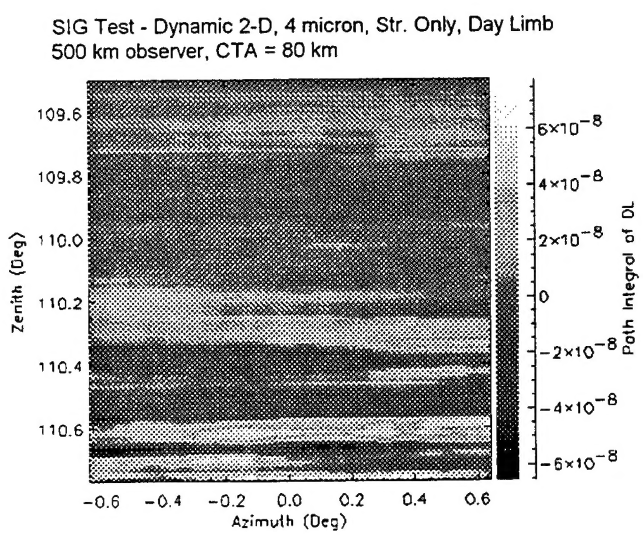
The following menu lists the test parameters used in the Quick Dynamic 2-D Limb View test case.

```
QUICK DYNAMIC SCENE GENERATION

    INPUT PARAMETERS

   1 =        12345 5 DIGIT RANDOM SEED NUMBER
   2 =          256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
   3 =         1024 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
   4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
   5 =          256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
   6 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
   7 = 8.000000E+01 BORE TANGENT ALTITUDE (KM)
   8 =            6 NUMBER OF VERTICAL AR COEFFICIENTS
   9 =           51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
```

Limb View Quick Dynamic 2-D Images



Synthetic Background + Structure Image



Synthetic Structure Image

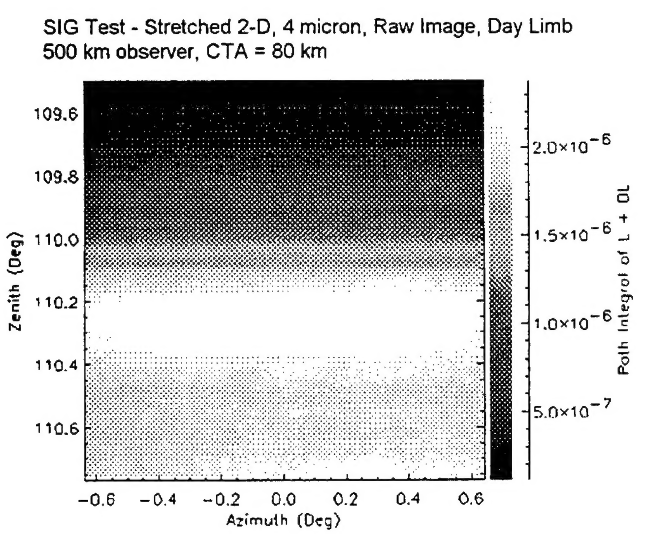
Test Case D Fast "Stretched Space" 2-D Limb View

The SHARC 4.0 Radiance Parameter output file, “SIGTST.2D”, was used in the Fast “Stretched Space” 2-D Limb View test case. The default file name for the “SIGTST.2D” file is “SHARCLC.DAT” (refer to Section 4.4.1.3).

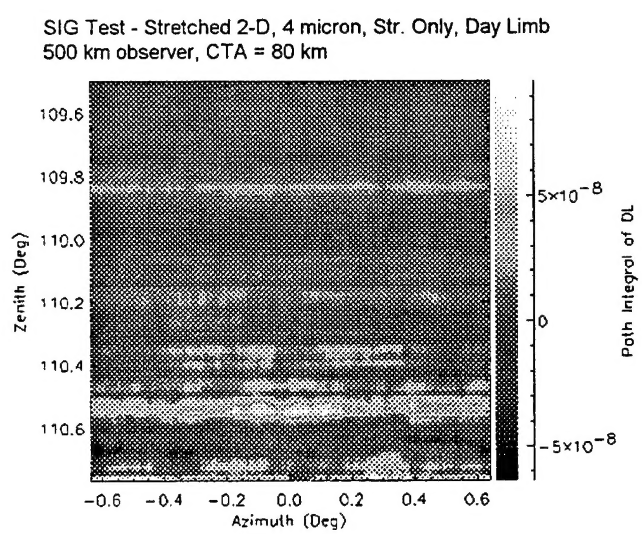
The following menu lists the test parameters used in the Fast “Stretched Space” 2-D Limb View test case.

```
FAST "STRETCHED SPACE" SCENE GENERATION

    INPUT PARAMETERS

   1 =         12345 5 DIGIT RANDOM SEED NUMBER
   2 = 1.666667E+00 SLOPE OF THE TRANSVERSE 1-D PSD
   3 = 3.000000E+00 SLOPE OF THE VERTICAL 1-D PSD
   4 =           256 NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
   5 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
   6 =           256 NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
   7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
   8 = 8.000000E+01 BORE TANGENT ALTITUDE (KM)
   9 =            51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
  10 =             6 NUMBER OF VERTICAL AR COEFFICIENTS (-1 => FT METHOD)
  11 =            -1 NUMBER OF TRANSVERSE AR COEFFICIENTS (-1 => FT METHOD)
```

Fast “Stretched Space” 2-D Limb View Images



Synthetic Background + Structure Image



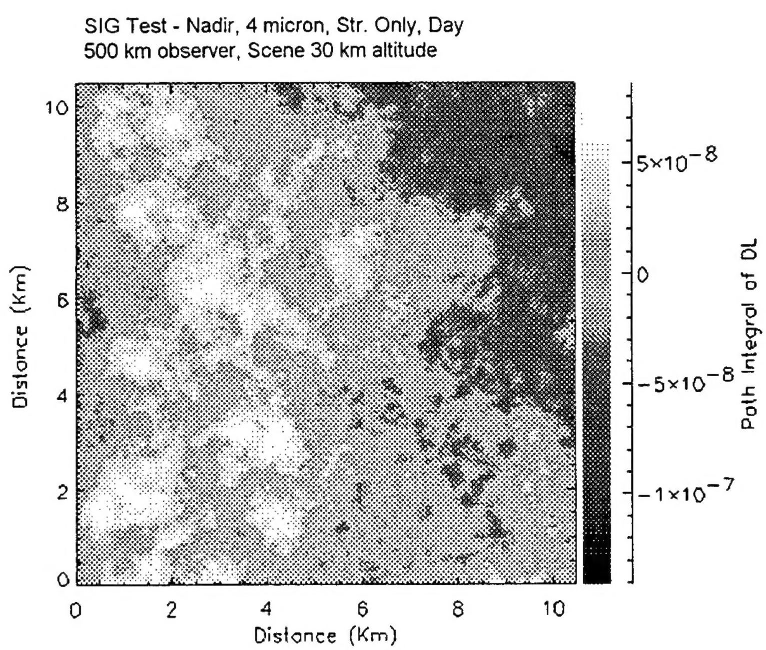
Synthetic Structure Image

Test Case E Nadir

The following menu lists the test parameters used in the Nadir test case.

```
NADIR RADIANCE IMAGE GENERATION

    INPUT PARAMETERS

   1 =         12345 5 DIGIT RANDOM NUMBER SEED
   2 = 5.000000E+02 SENSOR ALTITUDE (KM)
   3 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN X DIRECTION
   4 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN X DIR.
   5 = 5.000000E-03 IFOV OF X PIXEL (DEG)
   6 =           256 ACTUAL NUMBER OF PIXELS IN SIMULATED SCENE IN Y DIRECTION
   7 =          1024 NUMBER OF POINTS IN FFT USED TO SIMULATE SCENE IN Y DIR.
   8 = 5.000000E-03 IFOV OF Y PIXEL (DEG)
   9 = 3.000000E+01 SCENE ALTITUDE (KM)
  10 = 1.700000E+00 1-D PSD SLOPE
  11 = 8.460000E+00 CORRELATION LENGTH (KM)
  12 = 4.740000E-08 STANDARD DEVIATION OF SCENE
```

Nadir Image



Synthetic Structure Image

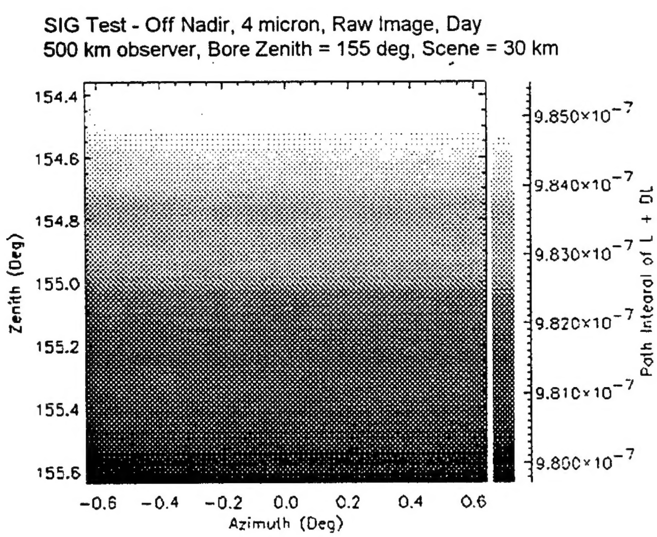
Test Case F Off-Nadir/Off-Vertical

The SHARC 4.0 Radiance Parameter output file, "SIGTSTDN.2D", was used in the Off-Nadir/Off-Vertical test case. The default file name for the "SIGTSTDN.2D" file is "SHARCLC.DAT" (refer to Section 4.4.1.3).

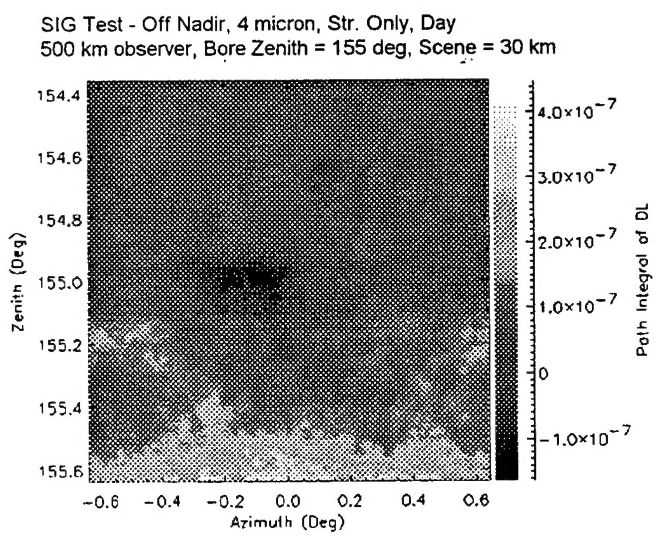
The following menu lists the test parameters used in the Off-Nadir/Off-Vertical test case.

```
OFF-NADIR SCENE GENERATION

    INPUT PARAMETERS

   1 =        12345 5 DIGIT RANDOM SEED NUMBER
   2 =          256 ACTUAL NUMBER OF TRANSVERSE PIXELS IN SIMULATED SCENE
   3 =          256 NUMBER OF TRANSVERSE POINTS IN FFT USED TO SIMULATE SCENE
   4 = 5.000000E-03 IFOV OF TRANSVERSE PIXEL (DEG)
   5 =         1024 NUMBER OF POINTS IN FFT ALONG THE LOS
   6 =          256 ACTUAL NUMBER OF VERTICAL PIXELS IN SIMULATED SCENE
   7 = 5.000000E-03 IFOV OF VERTICAL PIXEL (DEG)
   8 = 1.550000E+02 BORE ZENITH ANGLE (DEG)
   9 =            6 NUMBER OF VERTICAL AR COEFFICIENTS
  10 =           51 NUMBER OF VERTICAL FILTER RELAXATION VALUES
```

Off-Nadir/Off-Vertical Images



Synthetic Background + Structure Image



Synthetic Structure Image